K S INSTITUTE OF TECHNOLOGY BANGALORE

MECHANICAL ENGINEERING DEPARTMENT

COURSE FILE

NAME OF THE STAFF : ANILKUMAR A

SUBJECT CODE/NAME : 15ME52/ DYNAMICS OF MACHINERY

SEMESTER/YEAR : V/ III

ACADEMIC YEAR : 2018-2019

BRANCH : MECANICAL ENGINEERING

K. Rona

COURSE INCHARGE **HOD**

K. Rona

CHIEF ACADEMIC COORDINATOR **PRINCIPAL**

Date: 03.10.2018

Course files contents – Beginning of Semester

Sl. No.	Name of the Item
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1	Vision, Mission of Institute and Department
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K. S. INSTITUTE OF TECHNOLOGY

VISION: "To impart quality technical education with ethical values, employable skills and research to achieve excellence"

MISSION:

- To attract and retain highly qualified, experienced & committed faculty.
- To create relevant infrastructure
- Network with industry & premier institutions to encourage emergence of new ideas by providing research & development facilities to strive for academic excellence
- To inculcate the professional & ethical values among young students with employable skills & knowledge acquired to transform the society

DEPARTMENT OF MECHANICAL ENGINEERING

VISION: "To groom incumbents to compete with their professional peers in mechanical engineering that brings recognition"

MISSION:

- To impart sound fundamentals in mechanical engineering
- To expose students to new frontiers
- To achieve engineering excellence through experiential learning and team work.

PROGRAM EDUCATIONAL OBJECTIVES (PEO'S)

- To produce graduates who would have developed a strong background in basic science and mathematics and ability to use these tools in Mechanical Engineering.
- To prepare graduates who have the ability to demonstrate technical competence in their fields of Mechanical Engineering and develop solutions to the problems.
- To equip graduates to function effectively in a multi-disciplinary environment individually, within a global, societal, and environmental context.
- To create a sense of responsibility to promote of a team towards the fulfillment of both individual and organizational goals.

PROGRAM SPECIFIC OUTCOMES (PSO's)

It is expected that a student in mechanical engineering will possess an:

PSO1: Ability to apply concept of mechanical engineering to design a system, a component or a process/system to address a real world challenges

PSO2: Ability to develop effective communication, team work, entrepreneurial and computational skills

PROGRAM OUTCOMES (PO's)

Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

K.S INSTITUT E OF TECHNOLOGY, Bengaluru-109

CALENDAR OF EVENTS: ODD SEMESTER (2018-2019)

SESSION: AUG 2018 – DEC 2018 (3^{rd}, 5^{th} and 7^{th} Semester)

Week No.	Month	Day						Days	Activities
		Mon	Tue	Wed	Thu	Fri	Sat		
1	July/Aug	30*	31	1	2	3	4DH	5	30 - Comensement of 3rd anf 5th semester 4 - Declared Holiday
2	Aug	6*	7	8	9	10	11*	6	6-Comensement of 7th semester 11 - Inaguration of Ist semeter
3	Aug	13	14	15H	16	17	18	5	15 - Independence Day 18-Wednesday time table
4	Aug	20	21	22H	23	24DH	25	4	22-Bakrid 24 - Varamahalakshmi Vratham 25-Thursday time table
5	Aug/Sep	27	28	29	30	31	1	6	1-Friday time table
6	Sep	3	4	5	6	7	8DH	5	8 - Doclard Holiday
7	Sep	10	11TA	12H	13H	14T1	15T1	4	12-Gowri vratham 13-vinayaka chaturthi
8	Sep	17T1	18	19BV	20ASD	21H	22DH	4	21-Moharam last day
9	Sep	24	25	26	27	28	29	6	29 - Wednesday time table
10	Oct	1	2H	3	4	5	6	5	2-Gandhi Jayanthi 6 - Thursday time table
11	Oct	8H	9	10	11	12	13	5	8-Mahalaya Amavasya 13-Friday time table
12	Oct	15	16	17	18H	19H	20DH	3	18-Maharnavami 19-Vijayadasami
13	Oct/ Nov	22	23TA	24H	25T2	26T2	27T2	5	24-valmiki Jayanthi
14	Oct/Nov	29	30	31	1H	2BV	3ASD	5	1-kannada rajyothava 3-Wednesday time table
15	Nov	5	6H	7DH	8H	9	10	3	6-naraka chaturdasi 7-Amavasya 8-Balipadyami 10-Thursday time table
16	Nov	12	13	14	15	16	17	6	17-Friday time table
17	Nov	19	20TA	21H	22T3	23T3	24T3	5	21-Id Milad
18	Nov	26H	27LT	28LT	29LT	30LT BV	1LT ASD	5	26-kanakadasa Jayanthi
19	Dec	3	4					2	
TOTAL NO. of Working Days: 89									

H	Holiday
BV	Blue Book Verification
T1,T2,T3	Tests 1,2,3
ASD	Attendance & Sessional Display
DH	Declared Holiday
LT	Lab Test
TA	Test attendance

Total Number of working days (Excluding holidays and Tests)

Monday	16
Tuesday	16
Wednesday	14
Thursday	14
Friday	14
Total	74

5.8.18

PRINCIPAL
K.S. INSTITUTE OF TECHNOLOGY
BENGALURU - 560 109

K.S INSTITUT E OF TECHNOLOGY, Bengaluru-109

CALENDAR OF EVENTS: ODD SEMESTER (2018-2019)

DEPARTMENT OF MECHANICAL ENGINEEING

SESSION: AUG 2018 – DEC 2018 (3rd, 5th and 7th Semester)

Week No.	Month	Day						Days	Activities	Department Activities
		Mon	Tue	Wed	Thu	Fri	Sat			
1	July/Aug	30*	31	1	2	3	4DH	5	30 - Comensement of 3rd anf 5th semester 4 - Declared Holiday	
2	Aug	6*	7	8	9	10	11*	6	6-Comensement of 7th semester 11 - Inaguration of Ist semeter	
3	Aug	13	14	15H	16	17	18	5	15 - Independence Day 18-Wednesday time table	
4	Aug	20	21	22H	23	24DH	25	4	22-Bakrid 24 - Varamahalakshmi Vratham 25-Thursday time table	25 -Induction Program for 1st Year
5	Aug/Sep	27	28	29	30	31	1	6	1-Friday time table	
6	Sep	3	4	5	6	7	8DH	5	8 - Declard Holiday	
7	Sep	10	11 TA	12H	13H	14T1	15T1	4	12-Gowri vratham 13-vinayaka chaturthi	
8	Sep	17T1	18	19 BV	20 ASD	21H	22DH	4	21-Moharam last day	22 -Visit to IMTEX Exhibition
9	Sep	24	25	26	27	28	29	6	29 - Wednesday time table	
10	Oct	1	2H	3	4	5	6	5	2-Gandhi Jayanthi 6 - Thursday time table	4- Technical Talk on HVAC 5- Emanation presents - Un armed 2018
11	Oct	8H	9	10	11	12	13	5	8-Mahalaya Amavasya 13-Friday time table	13- Industrial Visit - VII Sem
12	Oct	15	16	17	18H	19H	20DH	3	18-Maharnavami 19-Vijayadasami	
13	Oct/ Nov	22	23 TA	24H	25T2	26T2	27T2	5	24-valmiki Jayanthi	
14	Oct/Nov	29	30	31	1H	2 BV	3 ASD	5	1-kannada rajyothava 3-Wednesday time table	3- Industrial Visit - V Sem
15	Nov	5	6H	7DH	8H	9	10	3	6-naraka chaturdasi 7-Amavasya 8-Balipadyami 10-Thursday time table	9th&10th Industrial Visit - III Sem
16	Nov	12	13	14	15	16	17	6	17-Friday time table	
17	Nov	19	20	21H	22T3	23T3	24T3	5	21-Id Milad	
18	Nov	26H	27LT	28LT	29LT	30LT BV	1LT ASD	5	26-kanakadasa Jayanthi	
19	Dec	3	4					2		
TOTAL NO. of Working Days: 89										

H	Holiday
BV	Blue Book Verification
T1,T2,T3	Tests 1,2,3
ASD	Attendance & Sessional Display
DH	Declared Holiday
LT	Lab Test
TA	Test attendance

Total Number of working days (Excluding holidays and Tests)

Monday	16
Tuesday	16
Wednesday	14
Thursday	14
Friday	14
Total	74

K. Rama

Signature of the HOD

Head of the Department
Dept. of Mechanical Engg.
K.S. Institute of Technology
Bengaluru - 560 109.

K.S. INSTITUTE OF TECHNOLOGY, BENGALURU - 560109
DEPARTMENT OF MECHANICAL ENGINEERING
ODD SEMESTER - Aug to Dec 2018

NAME : Anil Kumar A

PERIOD	1	2	3	4	5	6	7
TIME/ DAY	8:30 - 9:25	9:25 - 10:20	10:35 - 11:30	11:30 - 12:25	1:15 - 2:10	2:10 - 3:05	3:05 - 4:00
MON	CAMD LAB(A1)				DOM	DOM	
	IIIA				VB	VB	
TUE			CAMD	CAMD	CAMD LAB(A2)		
			IIIA	IIIA	IIIA		
WED	DOM	DOM					
	VB	VB					
THU		CAMD				DOM	
		IIIA				VB	
FRI					CAMD LAB(A3)		
					IIIA		
SAT							

HOD

Principal

K. S. INSTITUTE OF TECHNOLOGY, BENGALURU - 560109
DEPARTMENT OF MECHANICAL ENGINEERING
ODD SEMESTER - AUG to DEC 2018

Class Teacher : Mr.K.V.Manjunath

SECTION: VB

NEW BUILDING LH - 202

W.E.F: 30/07/2018

PERIOD	1	2	10:20 - 10.35	3	4	12:25 - 1:15	5	6	7
TIME/DAY	8:30 - 9:25	9:25 - 10:20		10:35 - 11:30	11:30 - 12:25		1:15 - 2:10	2:10 - 3:05	3:05 - 4:00
MON	DME-I	DME-I	TEA BREAK	TOE/NTM	EE/PM	Lunch Break	DOM	DOM	M&E
	AMR	AMR		GTR/NK	MKS/KVAB		AK	AK	KVM
TUE	FMML(B1)/EL(B2) →				DME-I		TOE/NTM	EE/PM	TM
	MKS/HU				AMR		GTR/NK	MKS/KVAB	KRN
WED	DOM	DOM		TM	TM		TOE/NTM	EE/PM	M&E
	AK	AK		KRN	KRN		GTR/NK	MKS/KVAB	KVM
THU	FMML(B3)/EL(B1) →				TOE/NTM		M&E	DOM	DME-I
	PBS/HU				GTR/NK		KVM	AK	AMR
FRI	TM	TM		DME-I	EE/PM		FMML(B2)/EL(B3)		
	KRN	KRN		AMR	MKS/KVAB		KVM/KP		
SAT									

15ME51	MANAGEMENT AND ENGINEERING ECONOMICS	Mr.K.V.Manjunath	15ME554	NON TRADITIONAL MACHINING-NTM	Mr.Naresh.K
15ME52	DYNAMICS OF MACHINERY-D0M	Mr.Anil Kumar.A	15ME562	ENERGY & ENVIRONMENT(OE-1)-EE	Mr.Muralidhar.K.S
15ME53	TURBO MACHINES-TM	Mr.K.Rama Narasimha	15ME564	PROJECT MANAGEMENT(OE1)-PM	Dr.K.V.A. Balaji
15ME54	DESIGN OF MACHINE ELEMENTS-1 -DME-1	Mr.Abhishek.M.R	15MEL57	FLUID MECHANICS & MACHINERY LAB	Mr.Muralidhara.K.S/ Mr.Prithviraj.B.S/Mr.K.V.Manjunath
15ME552	THEORY OF ELASTICITY (PE-I)-TOE	Mr.Girish.T.R	15MEL58	ENERGY LAB	Mr.Harish.U/Mr.K.Prasad

CO- ORDINATOR

K. Rama

Head of the Department
Dept. of Mechanical Engg.
Technology

HEAD OF THE DEPARTMENT

PRINCIPAL
K.S. INSTITUTE OF TECHNOLOGY
BENGALURU - 560 109

PRINCIPAL

K. S. INSTITUTE OF TECHNOLOGY

#14, Raghuvanahalli, Kanakapura Main Road, Bengaluru-5600109

DEPARTMENT OF MECHANICAL ENGINEERING

Course: DYNAMICS OF MACHINERY	Academic Year: 2018-2019
Course In charge : Mr.Anilkumar.A	
Type: **Core**	**Course Code:**15ME52

No of Hours per week

Theory (Lecture Class)	Practical/Field Work/Allied Activities	Total/Week	Total teaching hours
5	0	5	50

Marks

Internal Assessment	Examination	Total	Credits
20	80	100	4

Aim/Objective of the Course:

1. To gain the knowledge of static and dynamic equilibrium conditions of mechanisms subjected to forces and couple, with and without friction and working of fly wheel
2. To Analyze the mechanisms for static and dynamic equilibrium.
3. To understand the balancing principles of rotating and reciprocating masses, governors and gyroscopes.
4. Analyse the balancing of rotating and reciprocating masses, governors and gyroscopes.
5. To understand vibrations characteristics of single degree of freedom systems. Subjected to free and forced vibration with and without damping

Course Outcomes: After completing the course, the students will be able to,

15ME52.1	**Design** centrifugal governors and understand the gyroscopic effect on ships, aeroplanes & vehicles	Apply (K3)
15ME52.2	**Build** the concept of balancing rotating and reciprocating parts in machinery.	Apply (K3)
15ME52.3	**Identify** the effect of static and dynamic equilibrium of forces in planar mechanisms.	Apply (K3)
15ME52.4	**Examine** the concept of SHM and interpret natural frequencies of Undamped free vibrations.	Analyze (K4)
15ME52.5	**Inspect** the nature of damped free vibrations, Forced vibration of single degree freedom systems.	Analyze (K4)

Syllabus Content:	
Module 1:**Static force Analysis & Dynamic force Analysis** **Static force Analysis:** Static equilibrium. Equilibrium of two and three force members. Members with two forces and torque, Free body diagrams, Static force analysis of four bar mechanism and Slider-crank mechanism with and without friction. **Dynamic force Analysis:** D'Alembert principle, Inertia force, Inertia torque. Dynamic force analysis of four-bar mechanism and Slider crank mechanism without friction, numerical problems. LO: At the end of this session the student will be able to, 1. Define the equilibrium condition of two, three force member 2. Derive an expression of D'Alembert Priniciple. 3. Explain the construction of four bar & slider crank mechanism 4.	CO3 10hrs PO1-2 PO2-2 PO3-1 PO4-1 PO5-1 PO9-1

Module 2: **Balancing of Rotating Masses & Balancing of Reciprocating Masses** **Balancing of Rotating Masses:** Static and dynamic balancing, balancing of single rotating mass by balancing masses in same plane and in different planes. Balancing of several rotating masses by balancing masses in same plane and in different planes. **Balancing of Reciprocating Masses:** Inertia effect of crank and connecting rod, Single cylinder engine, balancing in multi cylinder-inline engine (primary and secondary forces), numerical problems. LO: At the end of this session the student will be able to, 1. Understand the concept of balancing, Static & Dynamic balancing of masses. 2. Explain the balancing of single rotating masses in same & different planes 3. Explain the concept of inertia effect of crank & connecting rod	CO2 10hrs. PO1-3 PO2-2 PO3-2 PO4-1 PO5-1 PO6-1 PO9-1 PO12-2
Module 3: **Governors & Gyroscope** **Governors:** Types of governors, force analysis of Porter and Hartnell governors. Controlling force, Stability, Sensitiveness, Isochronism, Effort and Power. **Gyroscope:** Vectorial representation of angular motion, Gyroscopic couple. Effect of gyroscopic couple on plane disc, aeroplane, ship, stability of two wheelers and	CO1 10hrs PO1-3 PO2-2 PO3-2

four wheelers, numerical problems. LO: At the end of this session the student will be able to, 1. Define and classify different types of governors 2. Explain the construction and working of hartnell & portor governor. 3. Explain the concept of gyroscope & its effect on ship, aeroplane, vehicles etc	PO4-2 PO5-2 PO6-1 PO8-2 PO9-1 PO12-2
Module 4: **Introduction & Undamped free Vibrations (Single Degree of Freedom)** Types of vibrations, Definitions, Simple Harmonic Motion (SHM), Work done by harmonic force, Principle of super position applied to SHM. Methods of analysis – (Newton's, Energy & Rayleigh's methods). Derivations for spring mass systems, Natural frequencies of simple systems, Springs in series and parallel, Torsional and transverse vibrations, Effect of mass of spring and problems LO: At the end of this session the student will be able to, 1. Understand the Concept of vibration, SHM, superposition principle 2. Apply the knowledge of Undamped & Damped Vibration in real time applications 3. Derive the expression for natural frequencies of Torsional & transverse vibrations.	CO4 10hrs PO1-3 PO2-2 PO3-1 PO4-1 PO5-1 PO6-1 PO9-1
Module 5: **Damped free Vibrations (Single Degree of Freedom) & Forced Vibration** Types of damping, Analysis with viscous damping - Derivations for over, critical and under damped systems, Logarithmic decrement and numerical problems. **Forced Vibrations (Single Degree of Freedom):** Analysis of forced vibration with constant harmonic excitation, Magnification factor (M.F.), Vibration isolation - Transmissibility ratio, Excitation of support (absolute and relative), Numerical problems. LO: At the end of this session the student will be able to, 1. Understand the concept of Damping and it`s types. 2. Derivation for the expression of damping factor for Over, critical & Under damped system 3. Derivation on logarithmic decrement & Application. 4. Determine the frequency of forced vibrations.	CO5 10hrs PO1-3 PO2-2 PO3-1 PO4-1 PO5-1 PO6-1 PO9-1

Text Books: -

1. Theory of Machines, Sadhu Singh, Pearson Education, 2nd Edition. 2007.

2. Theory of Machines, Rattan S.S. Tata McGraw Hill Publishing Company Ltd., New Delhi, 3rd Edition, 2009.

3. Mechanism and Machine Theory, A. G. Ambekar PHI, 2007

4. Mechanical Vibrations, G. K.Grover, Nem Chand and Bros.

Reference Books:

1.Mechanical Vibrations, S. S. Rao, Pearson Education Inc, 4edition, 2003.

2. Mechanical Vibrations, V. P. Singh, Dhanpat Rai and Company

Useful Websites

- http://www.sciencedirect.com/
- https://nptel.ac.in/courses/112104114/
- https://www.youtube.com/playlist?list=PL46AAEDA6ABAFCA78

Useful Journals

- Journal of sound and vibrations.
- International Journal of Dynamics and Control.

Teaching and Learning Methods:

1. Lecture class: 50 hrs.
2. Self-study: 0Hrs.
3. Field visits/Group Discussions/Seminars: 0Hrs
4. Practical classes/Labvisits: 3hrs.

Assessment:

Type of test/examination: Written examination
Continuous Internal Evaluation(CIE) : 20 marks (Average of best two of total three tests will be considered)

Semester End Exam(SEE) : 80 marks (students have to answer all main questions)
Test duration: 1 :30hr
Examination duration: 3 hrs

CO PO Mapping

PO1: Science and engineering Knowledge
PO2: Problem Analysis
PO3: Design & Development
PO4: Investigations of Complex Problems
PO5: Modern Tool Usage
PO6: Engineer & Society
PO7: Environment and Society
PO8: Ethics
PO9: Individual & Team Work
PO10: Communication
PO11: Project Mngmt & Finance
PO12: Life long Learning

PSO1: Ability to apply concept of mechanical engineering to design a system, a component or a process/system to address a real world challenges

PSO2: Ability to develop effective communication, team work, entrepreneurial and computational skills

CO/ 15 ME52	PO	PO1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
15ME52.1	K3	3	2	2	-	-	-	-	-	-	-	-	-	3	2
15ME52.2	K3	3	2	2	-	-	-	-	-	-	-	-	-	3	2
15ME52.3	K3	2	2	2	-	-	-	-	-	-	-	-	-	3	1
15ME52.4	K4	3	2	1	-	-	-	-	-	-	-	-	-	3	1
15ME52.5	K4	3	2	1	-	-	-	-	-	-	-	-	-	3	1
Average		**2.8**	**2**	**1.40**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.40**

Signature of course in charge

Signature of Module Coordinator

signature of HOD/ME

Head of the Department
Dept. of Mechanical Engg
K.S. Institute of Technology
Bengaluru - 560 109.

Signature of Chief Academic Coordinator

ACADEMIC CO-ORDINATOR
K.S. Institute of Technology
Bengaluru - 560 109

Signature of Principal

KS INSTITUTE OF TECHNOLOGY BANGALORE

DEPARTMENT OF MECHANICAL ENGINEERING

SYLLABUS

Year/Sem/ Section: III / V/ 'B'

SUBJECT CODE/TITLE: 15ME52/DYNAMICS OF MACHINERY

Course objectives:

1. To gain the knowledge of static and dynamic equilibrium conditions of mechanisms subjected to forces and couple, with and without friction and working of fly wheel
2. To analyze the mechanisms for static and dynamic equilibrium.
3. To understand the balancing principles of rotating and reciprocating masses, governors and gyroscopes.
4. Analyse the balancing of rotating and reciprocating masses, governors and gyroscopes.
5. To understand vibrations characteristics of single degree of freedom systems. Subjected to free and forced vibration with and without damping

Course Outcomes:

CO1: Design centrifugal governors and understand the gyroscopic effect on ships, aeroplanes & vehicles
CO2: Build the concept of balancing of rotating and reciprocating parts in machinery.
CO3: Identify the effect of static and dynamic equilibrium of forces in planar mechanisms.
CO4: Examine the concept of SHM and interpret natural frequencies of Undamped free vibrations.
CO5: Inspect the nature of damped free vibrations, Forced vibration of single degree freedom systems.

MODULE 1: Static and Dynamic Force Analysis

Static force Analysis: Static equilibrium, Equilibrium of two and three force members. Members with two forces and torque, free body diagrams, Static force analysis of four bar mechanism and Slider-crank mechanism with and without friction.

Dynamic force Analysis: D'Alembert's principle, Inertia force, Inertia torque. Dynamic force analysis of four-bar mechanism and Slider crank mechanism without friction, numerical problems.

10 Hours

MODULE 2: Balancing of Rotating & Reciprocating Masses

Balancing of Rotating Masses: Static and dynamic balancing, balancing of single rotating mass by balancing masses in same plane and in different planes. Balancing of several rotating masses by balancing masses in same plane and in different planes.

Balancing of Reciprocating Masses: Inertia effect of crank and connecting rod, Single cylinder engine, balancing in multi cylinder-inline engine (primary and secondary forces), numerical problems.

10 Hours

MODULE 3: Governors & Gyroscopes

Governors: Types of governors, force analysis of Porter and Hartnell governors. Controlling force, Stability, Sensitiveness, Isochronism, Effort and Power.

Gyroscope: Vectorial representation of angular motion, gyroscopic couple. Effect of gyroscopic couple on plane disc, aeroplane, ship, stability of two wheelers and four wheelers, numerical problems.

10 Hours

MODULE 4: Introduction to Vibrations

Introduction & Undamped free Vibrations (Single Degree of Freedom): Types of vibrations, Definitions, Simple Harmonic Motion (SHM), Work done by harmonic force, Principle of super position applied to SHM. Methods of analysis – (Newton's, Energy & Rayleigh's methods). Derivations for spring mass systems, Natural frequencies of simple systems, springs in series and parallel, Torsional and transverse vibrations, Effect of mass of spring and problems.

10 Hours

M0DULE5: Damped & Forced Vibrations

Damped free Vibrations (Single Degree of Freedom): Types of damping, Analysis with viscous damping - Derivations for over, critical and under damped systems, Logarithmic decrement and numerical problems.
Forced Vibrations (Single Degree of Freedom): Analysis of forced vibration with constant harmonic excitation, Magnification factor (M.F.), Vibration isolation - Transmissibility ratio, Excitation of support (absolute and relative), Numerical problems.

10 Hours

Text Books:

1. Sadhu Singh, "**Theory of Machines**", Pearson Education, 2nd Edition, 2007.
2. Ambekar A. G., "**Mechanism and Machine Theory**", PHI, 2009.
3. V.P.Singh, "**Mechanical Vibrations**", Dhanpat Rai and Company.
4. G.K.Grover, "**Mechanical Vibrations**", Nem Cand and Bros.

Reference Books:

1. S.S.Rattan, "**Theory of Machines**", Tata McGraw Hill Publishing Company Ltd., New Delhi, 3rd Edition, 2009.
2. S.S.Rao, "**Mechanical Vibrations",** Pearson Education Inc, 4th edition, 2003.

Signature of course in charge

Signature of Module Coordinator

signature of HOD/ME

Head of the Department
Dept. of Mechanical Engg.
K.S. Institute of Technology
Bengaluru - 560 109.

Signature of Chief Academic Coordinator

ACADEMIC CO-ORDINATOR
K.S. Institute of Technology
Bengaluru - 560 109.

2.11.18

Signature of Principal

KS INSTITUTE OF TECHNOLOGY BANGALORE

DEPARTMENT OF MECHANICAL ENGINEERING

NAME OF THE STAFF : Mr. A ANIL KUMAR

SUBJECT CODE/NAME : 15ME52/ DYNAMICS OF MACHINERY

SEMESTER/YEAR : V / III

ACADEMIC YEAR : 2018-2019

Sl. No.	Topic to be covered	Mode of Delivery	Teaching Aid	No. of Periods	Cumulative No. of Periods	Proposed Date
	MODULE 3:Governors & Gyroscope					
1	**Governors:** Types of governors	L+I	LCD	2	2	30/7/2018
2	Controlling force, Stability, Sensitiveness, Isochronism, Effort and Power of a Governor.	L+ D	BB	1	3	1/8/2018
3	Force analysis of Porter Governor.	L+ D	BB	1	4	1/8/2018
4	Numerical Problems on Porter Governor	L+D	BB	3	7	2/8/2018 6/8/2018 6/8/2018
5	Force analysis of Hartnell Governor.	L+D	BB	1	8	8/8/2018
6	Numerical Problems on Hartnell Governor	L+D	BB	3	11	8/8/2018 9/8/2018 13/8/2018
7	**Gyroscope:** Vectorial representation of angular motion, Gyroscopic couple	L+I	LCD	2	13	13/8/2018 16/8/2018
8	Effect of gyroscopic couple on plane disc, aeroplane, ship	L+D	BB, Lab Visit	2	15	18/8/2018 18/8/2018
9	Stability of two wheelers and four wheelers	L+D	BB	1	16	20/8/2018
10	Numerical problems.	L+ D	BB,PS	3	19	20/8/2018 23/8/2018 25/8/2018
	MODULE 2:Balancing of Rotating Masses & Balancing of Reciprocating Masses					
11	**Balancing of Rotating Masses:** Static and dynamic balancing	L+ D	LCD	1	20	27/8/2018
12	Balancing of single rotating mass by balancing masses in same plane and in different planes	L+D	BB	1	21	27/8/2018

13	Balancing of several rotating masses by balancing masses in same plane and in different planes.	L+D	BB, Lab Visit	2	23	28/8/2018 28/8/2018
14	Numerical Problems on Rotating Masses in same plane.	L+D	BB	1	24	30/8/2018
15	Numerical Problems on Rotating Masses in Different planes.	L+D	BB	2	26	3/9/2018 3/9/2018
16	**Balancing of Reciprocating Masses:** Inertia effect of crank and connecting rod	L+D	BB	2	28	5/9/2018 5/9/2018
17	Balancing of Single cylinder engine	PS	BB	1	29	6/9/2018
MODULE 4:Introduction & Undamped free Vibrations (Single Degree of Freedom)						
18	Types of vibrations, Definitions, Simple Harmonic Motion (SHM)	L+I	LCD	2	31	10/9/2018 10/9/2018
19	TEST-1	-	-	1	32	14/09/2018
20	Balancing in multi cylinder-inline engine (primary and secondary forces)	L+D, LW	BB	1	33	19/9/2018
21	Numerical Problems on Balancing of Reciprocating Masses.	L+D	BB,PS	5	38	19/9/2018 20/9/2018 24/9/2018 24/9/2018 26/9/2018
MODULE 1:Static force Analysis & Dynamic force Analysis						
22	**Static force Analysis:** Static equilibrium	L+D	BB+LCD	1	39	26/9/2018
23	Equilibrium of two and three force members. Members with two forces and torque, Free body diagrams	L+I	BB+LCD	1	40	27/9/2018
24	Static force analysis of four bar mechanism and Slider-crank mechanism with and without friction.	L+D	BB	2	42	29/9/2018 29/9/2018
25	Numerical Problems on Static Force analysis	PS	BB	3	45	1/10/2018 1/10/2018 3/10/2018
26	**Dynamic force Analysis:** D'Alembert principle, Inertia force, Inertia torque	L+D	BB	2	47	3/10/2018 4/10/2018
27	Dynamic force analysis of four-bar mechanism and Slider crank mechanism without friction, numerical problems.	L+D	BB	2	49	6/10/2018 10/10/2018
28	Numerical Problems on Dynamic Force analysis	L+D	BB	3	52	10/10/2018 11/10/2018 15/10/2018
MODULE 4:Introduction & Undamped free Vibrations (Single Degree of Freedom)						
29	Work done by harmonic force, Principle of super position	L+I	LCD	1	53	15/10/2018

30	Numerical Problems on SHM & Principle of Superposition	L+D	BB	1	54	17/10/2018
31	Methods of analysis – (Newton's, Energy & Rayleigh's methods). Derivations for spring mass systems, Natural frequencies of simple systems, Springs in series and parallel, Torsional and transverse vibrations, Effect of mass of spring and Numerical problems	L+D	BB	2	56	17/10/2018 22/10/2018
32	Types of damping, Analysis with viscous damping	L+D	BB, Lab Visit	2	58	22/10/2018
33	TEST-2	-	-	1	59	25/10/2018
34	Numerical Problems on Newton's method.	L+D	BB	2	61	29/10/2018 31/10/2018
35	Numerical Problems on Energy method.	L+D, PS	BB	1	62	31/10/2018
36	Numerical Problems on Rayleigh's method.	L+D	BB, PS	1	63	3/11/2018
MODULE 5: Damped free Vibrations (Single Degree of Freedom) & Forced Vibration						
37	Types of damping, Analysis with viscous damping	L+D	BB	2	65	3/11/2018
38	Derivations for over, critical and under damped systems	L+I	BB, LCD	1	66	5/11/2018
39	Logarithmic decrement and numerical problems.	L+D	BB	1	67	5/11/2018
40	Numerical Problems.	L+D	BB, PS	3	70	10/11/2018 12/11/2018 12/11/2018
41	**Forced Vibrations (Single Degree of Freedom):** Analysis of forced vibration with constant harmonic excitation	L+I	BB, LCD	1	71	14/11/2018
42	Magnification factor (M.F.), Vibration isolation - Transmissibility ratio	L+D	BB	1	72	14/11/2018
43	Excitation of support (absolute and relative), Numerical problems.	L+D	BB	1	73	15/11/2018
44	Numerical problems.	L+D	BB	2	75	19/11/2018 19/11/2018
45	TEST-3	-	-	1	76	22/11/2018

K. Rama

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2.11.18

ACADEMIC CO-ORDINATOR
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KSIT BANGLORE

DEPARTMENT OF MECHANICAL ENGINEERING

STUDENTS DETAILS

Year/Semester/Section: **3RD YEAR/ 5TH SEM/ 'B' SEC**

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SET – A

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109

I SESSIONAL TEST QUESTION PAPER 2018 – 19 ODD SEMESTER

USN										

Degree	:	**B.E**	**Semester**	:	**V A & B**
Branch	:	**Mechanical Engineering**	**Course Code**	:	**15ME52**
Course Title	:	**DYNAMICS OF MACHINERY**	**Date**	:	**14-09-2018**
Duration	:	**90 Minutes**	**Max Marks**	:	**30**

Note: Answer ONE full question from each part.

Q No.	Question	Marks	CO mapping	K-Level
	PART-A			
[illegible])	**Explain** the following terms with respect to the governors i) Sensitiveness ii) Isochronism iii) Hunting iv) Governor Power v) Controlling force	5	CO1	UNDERSTAND (K2)
(b)	In an engine governor of porter type, the upper and lower arms are 200mm and 250mm respectively and pivoted on the axis of rotation. The mass of central load is 15kg, the mass of each ball is 2kg and friction at the sleeve together with the resistance of the operating gear is equal to a load of 24N at the sleeve. If the limiting inclinations of the upper arms to the verticals are 30^0 and 40^0. **Find** taking friction in to account range of speed of the governor.	5	CO1	APPLY (K3)
(c)	**List** and Explain different types of vibrations.	5	CO4	ANALYZE (K4)
	OR			
2(a)	**Show** that speed of a porter governor is given by $N^2 = \left\{\frac{mg + \left(\frac{Mg \pm F}{2}\right)(1+K)}{mg}\right\} X \frac{895}{h}$	5	CO1	UNDERSTAND (K2)
(b)	In a spring loaded Hartnell type governor, the extreme radii of rotation of balls are 80mm and 120mm. The ball arm and the sleeve arm of the bell crank lever are equal in length. The mass of each ball is 2kg, If the speed at the two extreme positions are 400 and 420 rpm. **Determine** i) The initial compression of the central spring. ii) The spring constant.	5	CO1	APPLY (K3)
(c)	**Explain** the following terms: i) Simple harmonic motion ii) Frequency iii) Natural Frequency iv) Resonance v) Degrees of freedom	5	CO4	UNDERSTAND (K2)

PART-B				
3(a)	The arms of a porter governor are 300mm long. The upper arms are pivoted on the axis of revolution. The lower arms are attached to the sleeve at a distance of 40mm from the axis of rotation. The mass of the load on the sleeve is 70kg and mass of each ball is 10kg. **Find** the equilibrium speed when the radius of rotation of the ball is 200mm. If the friction is equivalent to 20N at the sleeve, what will be the range of speed for this position?	**5**	**CO1**	**APPLY (K3)**
(b)	In a Hartnell governor the length of ball and sleeve arms are 12cm & 10cm respectively. The distance of fulcrum of the bell crank lever from the governor axis is 14cm. Mass of each governor ball is 4kg. When the governor runs at mean speed of 300rpm, the ball arm is vertical & sleeve arm is horizontal. For an increase in speed of 4% the sleeve moves 10mm upwards, neglecting the friction, **Calculate** i) Minimum equilibrium speed if the total sleeve movement is 20mm. ii) Spring stiffness iii) Sensitiveness of Governor. iv) Spring stiffness if the governor is to be Isochronous at 300rpm.	**5**	**CO1**	**APPLY (K3)**
(c)	**Explain** Static and Dynamic balancing of a system of revolving masses.	**5**	**CO2**	**UNDERSTAND (K2)**
OR				
4(a)	All the arms of a porter governor are 178mm long and are hinged at 38mm from the axis of rotation. The mass of each ball is 1.15 kg and mass of sleeve is 20kg. The governor sleeve begins to raise at 280 rpm, when the links are at an angle of 30^0 to the vertical. Assuming the frictional force to be constant, **Determine** the maximum and minimum speed of rotation when the inclination of the arms to the vertical is 45^0.	**5**	**CO1**	**APPLY (K3)**
(b)	A Hartnell type spring loaded governor rotates about vertical axis. The two rotating masses of 1kg each moves at a radius of 0.12m, when the speed is 550rpm. The arms of 100mm & 75mm length are vertical and horizontal, when the equilibrium speed is 575rpm & the rotating masses are at their maximum radius of 145mm. **Calculate** i) The stiffness of the spring & initial compression at 550rpm. ii) Radius at which the masses rotate when the equilibrium speed is 525rpm.	**5**	**CO1**	**APPLY (K3)**
(c)	**Explain** balancing of several masses rotating in same plane and in different planes.	**5**	**CO2**	**UNDERSTAND (K2)**

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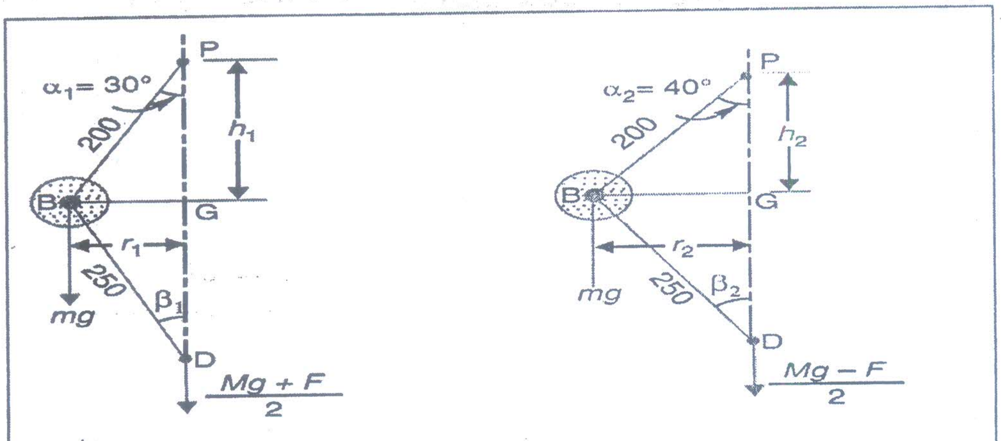
K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109
I SESSIONAL TEST QUESTION PAPER 2018 – 19 ODD SEMESTER

SCHEME AND SOLUTION

Degree : B.E **Semester** : V A & B
Branch : Mechanical Engineering **Course Code** : 15ME52
Course Title : DYNAMICS OF MACHINERY **Max Marks** : 30

Q.NO.	POINTS	MARKS
1(a)	i) **Sensitivity**: Sensitivity of a governor is defined as the ratio of difference between maximum speed & minimum speed to mean speed.	1M
	ii) **Isochronous**: A governor is said to be isochronous if, neglecting friction, the equilibrium speed is the same for all radii of the balls.	1M
	iii) **Hunting:** The continuous process of governor fluctuating above and below the mean speed is called as Hunting.	1M
	iv) **Power** is the work done on the sleeve for the given percentage change of speed. **Governor Power = Mean Effort X Lift of sleeve**	1M
	v) **Controlling force:** Controlling Force is the inward radial force exerted on each ball of a centrifugal governor by the arms, spring, etc. which are attached to it.	1M
1(b)	 All dimensions in mm. (*a*) Minimum position. (*b*) Maximum position.	1M
	Let, N1= Minimum speed and N2= Maximum speed From figure, we find that minimum radius of rotation, R_1= BG=BPsin30^0=0.2*0.5=0.1m Height of the governor: h_1=PG=BPcos30^0=0.2*0.866=0.1732m.	

$$DG = \sqrt{(BD)^2 - (BG)^2} = \sqrt{(0.25)^2 - (0.1)^2} = 0.23 \text{ m}$$

$$\tan \beta_1 = BG/DG = 0.1/0.23 = 0.4348$$

$$\tan \alpha_1 = \tan 30° = 0.5774$$

$$\therefore \quad q_1 = \frac{\tan \beta_1}{\tan \alpha_1} = \frac{0.4348}{0.5774} = 0.753$$

We know that when the sleeve moves downwards, the frictional force (*F*) acts upwards and the minimum speed is given by

$$(N_1)^2 = \frac{m.g + \left(\frac{M.g - F}{2}\right)(1 + q_1)}{m.g} \times \frac{895}{h_1}$$

$$= \frac{2 \times 9.81 + \left(\frac{15 \times 9.81 - 24}{2}\right)(1 + 0.753)}{2 \times 9.81} \times \frac{895}{0.1732} = 33596$$

$$\therefore \quad N_1 = 183.3 \text{ r.p.m.}$$

2M

From figure (b) we find that maximum radius of rotation,

$$r_2 = BG = BP \sin 40° = 0.2 \times 0.643 = 0.1268 \text{ m}$$

Height of the governor,

$$h_2 = PG = BP \cos 40° = 0.2 \times 0.766 = 0.1532 \text{ m}$$

and

$$DG = \sqrt{(BD)^2 - (BG)^2} = \sqrt{(0.25)^2 - (0.1268)^2} = 0.2154 \text{ m}$$

$$\therefore \quad \tan \beta_2 = BG/DG = 0.1268 / 0.2154 = 0.59$$

and

$$\tan \alpha_2 = \tan 40° = 0.839$$

$$\therefore \quad q_2 = \frac{\tan \beta_2}{\tan \alpha_2} = \frac{0.59}{0.839} = 0.703$$

We know that when the sleeve moves upwards, the frictional force (*F*) acts downwards and the maximum speed is given by

$$(N_2)^2 = \frac{m.g + \left(\frac{m.g + F}{2}\right)(1 + q_2)}{m.g} \times \frac{895}{h_2}$$

$$= \frac{2 \times 9.81 + \left(\frac{15 \times 9.81 + 24}{2}\right)(1 + 0.703)}{2 \times 9.81} \times \frac{895}{0.1532} = 49\,236$$

$$\therefore \quad N_2 = 222 \text{ r.p.m.}$$

We know that range of speed

$$= N_2 - N_1 = 222 - 183.3 = 38.7 \text{ r.p.m.}$$ **Ans.**

2M

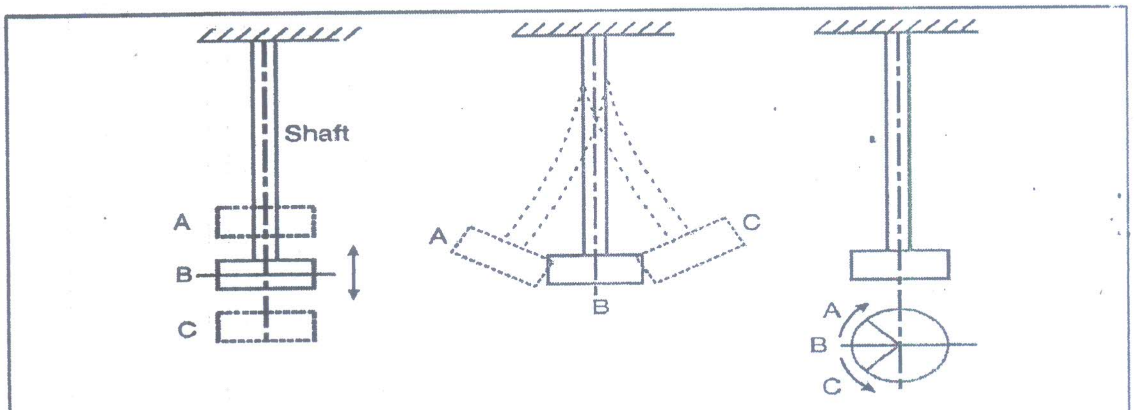
1(c)

1. *Free or natural vibrations.* When no external force acts on the body, after giving it an initial displacement, then the body is said to be under *free or natural vibrations*. The frequency of the free vibrations is called *free or natural frequency.* 2M

2. *Forced vibrations.* When the body vibrates under the influence of external force, then the body is said to be under *forced vibrations*. The external force applied to the body is a periodic disturbing force created by unbalance. The vibrations have the same frequency as the applied force.

Note : When the frequency of the external force is same as that of the natural vibrations, resonance takes place.

3. *Damped vibrations.* When there is a reduction in amplitude over every cycle of vibration, the motion is said to be *damped vibration*. This is due to the fact that a certain amount of energy possessed by the vibrating system is always dissipated in overcoming frictional resistances to the motion.



1M

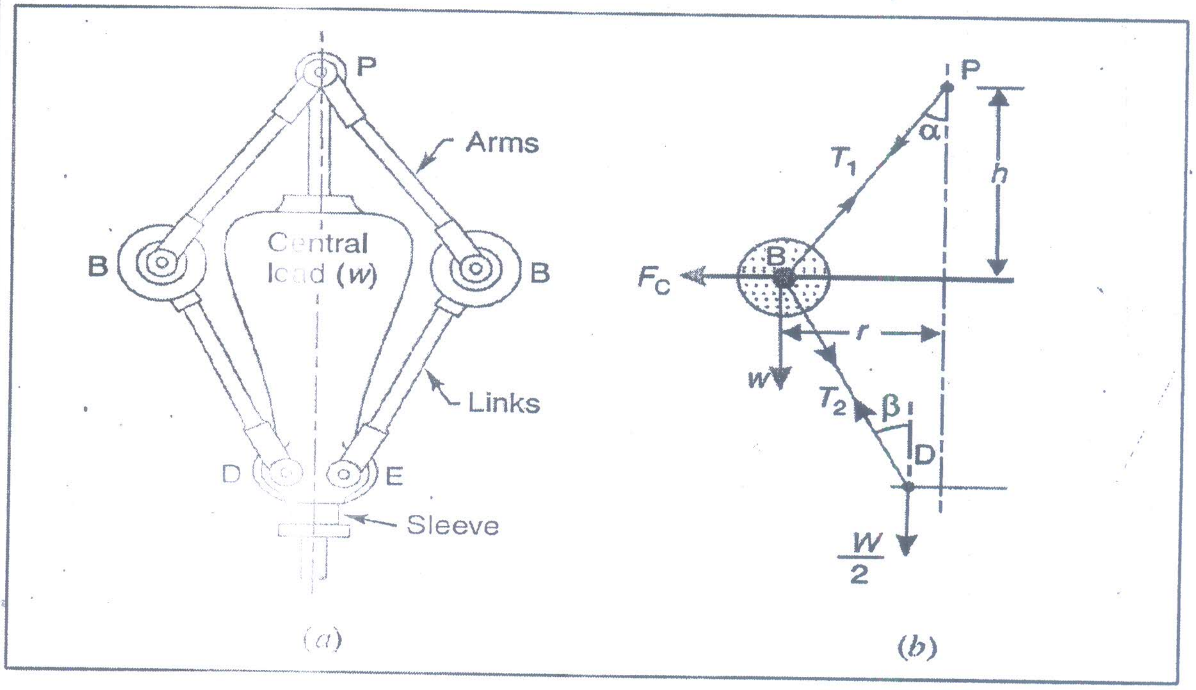
B = Mean position ; A and C = Extreme positions.

(*a*) Longitudinal vibrations. (*b*) Transverse vibrations. (*c*) Torsional vibrations.

1. *Longitudinal vibrations.* When the particles of the shaft or disc moves parallel to the axis of the shaft, as shown in Fig. 23.1 (*a*), then the vibrations are known as *longitudinal vibrations*. In this case, the shaft is elongated and shortened alternately and thus the tensile and compressive stresses are induced alternately in the shaft. 2M

2. *Transverse vibrations.* When the particles of the shaft or disc move approximately perpendicular to the axis of the shaft, as shown in Fig. 23.1 (*b*), then the vibrations are known as *transverse vibrations*. In this case, the shaft is straight and bent alternately and bending stresses are induced in the shaft.

3. *Torsional vibrations**. When the particles of the shaft or disc move in a circle about the axis of the shaft, as shown in Fig. 23.1 (*c*), then the vibrations are known as *torsional vibrations*. In this case, the shaft is twisted and untwisted alternately and the torsional shear stresses are induced in the shaft.

Q.NO.	POINTS	M
2(a)	 (*a*) (*b*) m = Mass of each ball in kg, w = Weight of each ball in newtons = $m.g$, M = Mass of the central load in kg, W = Weight of the central load in newtons = $M.g$, r = Radius of rotation in metres, h = Height of governor in metres , N = Speed of the balls in r.p.m ., ω = Angular speed of the balls in rad/s = $2\pi N/60$ rad/s, F_C = Centrifugal force acting on the ball in newtons = $m.\omega^2.r$, T_1 = Force in the arm in newtons, T_2 = Force in the link in newtons, α = Angle of inclination of the arm (or upper link) to the vertical, and β = Angle of inclination of the link (or lower link) to the vertical.	1M

Considering the equilibrium of the forces acting at D, we have

$$T_2 \cos\beta = \frac{W}{2} = \frac{M.g}{2}$$

or

$$T_2 = \frac{M.g}{2\cos\beta}$$

Again, considering the equilibrium of the forces acting on B. The point B is in equilibrium under the action of the following forces, as shown in Fig. 18.3 (*b*).

(*i*) The weight of ball ($w = m.g$),

(*ii*) The centrifugal force (F_C),

(*iii*) The tension in the arm (T_1), and

(*iv*) The tension in the link (T_2).

Resolving the forces vertically,

$$T_1\cos\alpha = T_2\cos\beta + w = \frac{M.g}{2} + m.g \qquad \ldots(ii)$$

$$\ldots\left(\because\ T_2\cos\beta = \frac{M.g}{2}\right)$$

Resolving the forces horizontally,

$$T_1\sin\alpha + T_2\sin\beta = F_C$$

$$T_1\sin\alpha + \frac{M.g}{2\cos\beta}\times\sin\beta = F_C \qquad \ldots\left(\because\ T_2 = \frac{M.g}{2\cos\beta}\right)$$

$$T_1\sin\alpha + \frac{M.g}{2}\times\tan\beta = F_C$$

$$\therefore \quad T_1\sin\alpha = F_C - \frac{M.g}{2}\times\tan\beta \qquad \ldots(iii)$$

Dividing equation (*iii*) by equation (*ii*),

$$\frac{T_1\sin\alpha}{T_1\cos\alpha} = \frac{F_C - \frac{M.g}{2}\times\tan\beta}{\frac{M.g}{2} + m.g}$$

or

$$\left(\frac{M.g}{2} + m.g\right)\tan\alpha = F_C - \frac{M.g}{2}\times\tan\beta$$

$$\frac{M.g}{2} + m.g = \frac{F_C}{\tan\alpha} - \frac{M.g}{2}\times\frac{\tan\beta}{\tan\alpha}$$

Substituting $\frac{\tan\beta}{\tan\alpha} = q$. and $\tan\alpha = \frac{r}{h}$, we have

$$\frac{M.g}{2} + m.g = m.\omega^2.r\times\frac{h}{r} - \frac{M.g}{2}\times q \qquad \ldots(\therefore\ F_C = m.\omega^2.r)$$

or

$$m.\omega^2.h = m.g + \frac{M.g}{2}(1+q)$$

2M

$$\therefore \quad h = \left[m.g + \frac{M.g}{2}(1+q)\right]\frac{1}{m.\omega^2} = \frac{m + \frac{M}{2}(1+q)}{m}\times\frac{g}{\omega^2} \qquad \ldots(iv)$$

or

$$\omega^2 = \left[m.g + \frac{Mg}{2}(1+q)\right]\frac{1}{m.h} = \frac{m + \frac{M}{2}(1+q)}{m}\times\frac{g}{h}$$

or

$$\left(\frac{2\pi N}{60}\right)^2 = \frac{m + \frac{M}{2}(1+q)}{m}\times\frac{g}{h}$$

$$\therefore \quad N^2 = \frac{m + \frac{M}{2}(1+q)}{m}\times\frac{g}{h}\left(\frac{60}{2\pi}\right)^2 = \frac{m + \frac{M}{2}(1+q)}{m}\times\frac{895}{h} \qquad \ldots(v)$$

$$\ldots(\text{Taking } g = 9.81 \text{ m/s}^2)$$

If F = Frictional force acting on the sleeve in newtons, then the equations (*v*) and (*vi*) may be written as

$$N^2 = \frac{m.g + \left(\frac{M.g \pm F}{2}\right)(1+q)}{m.g} \times \frac{895}{h} \qquad \ldots (vii)$$

$$= \frac{m.g + (M.g \pm F)}{m.g} \times \frac{895}{h} \qquad \ldots (\text{When } q = 1) \ldots (viii)$$

2M

2(b) **Solution.** Given : r_1 = 80 mm = 0.08 m ; r_2 = 120 mm = 0.12 m ; $x = y$; m = 2 kg ; N_1 = 400 r.p.m. or $\omega = 2\pi \times 400/60 = 41.9$ rad/s ; N_2 = 420 r.p.m. or $\omega_2 = 2\pi \times 420/60 = 44$ rad/s

Initial compression of the central spring

We know that the centrifugal force at the minimum speed,

$$F_{C1} = m(\omega_1)^2 r_1 = 2(41.9)^2\ 0.08 = 281 \text{ N}$$

and centrifugal force at the maximum speed,

$$F_{C2} = m(\omega_2)^2 r_2 = 2(44)^2\ 0.12 = 465 \text{ N}$$

Let S_1 = Spring force at the minimum speed, and

S_2 = Spring force at the maximum speed.

We know that for minimum position,

$$M.g + S_1 = 2F_{C1} \times \frac{x}{y}$$

$$\therefore \quad S_1 = 2F_{C1} = 2 \times 281 = 562 \text{ N} \qquad \ldots (\because M = 0 \text{ and } x = y)$$ 1M

Similarly for maximum position,

$$M.g + S_2 = 2F_{C2} \times \frac{x}{y}$$ 1M

$$\therefore \quad S_2 = 2F_{C2} = 2 \times 465 = 930 \text{ N}$$

We know that lift of the sleeve,

$$h = (r_2 - r_1)\frac{y}{x} = r_2 - r_1 = 120 - 80 = 40 \text{ mm} \qquad \ldots (\because x = y)$$

∴ Stiffness of the spring,

$$s = \frac{S_2 - S_1}{h} = \frac{930 - 562}{40} = 9.2 \text{ N/mm}$$ 1M

We know that initial compression of the central spring

$$= \frac{S_1}{s} = \frac{562}{9.2} = 61 \text{ mm Ans.}$$ 1M

2. ***Spring constant***

We have calculated above that the spring constant or stiffness of the spring,

$$s = 9.2 \text{ N/mm Ans.}$$ 1M

2(c)
i) **Simple Harmonic Motion:** Simple harmonic motion is the simplest type of periodic motion in which acceleration is always directed towards the mean position and is proportional to the displacement. 1M

ii) **Frequency:** The number of cycles per unit time is called as frequency. It is usually represented [illegible] per second. 1M

iii) **Natural frequency:** After giving an initial displacement from the equilibrium position, if the system is left to vibrate on its own with out any external forces, the frequency wit which it vibrates is known as Natural frequency. 1M

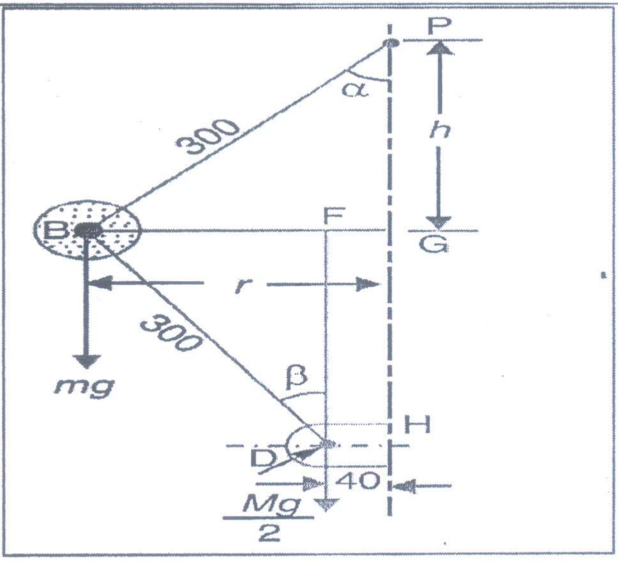
iv) **Resonance:** The vibration of the system when the frequency of the external excitations is equal to the natural frequency of the vibrating body is called as Resonance.

v) **Degrees of Freedom:** The minimum number of co-ordinates required to describe the motion of q system at any instant is called as Degrees of freedom. 1M

1M

PART-B

Q.NO.	POINTS	MARKS
3(a)		1M



Equilibrium speed when the radius of rotation r = BG = 200 mm

Let N = Equilibrium speed.

The equilibrium position of the governor is shown in Fig. 18.9. From the figure, we find that . height of the governor,

$$h = PG = \sqrt{(BP)^2 - (BG)^2} = \sqrt{(300)^2 - (200)^2} = 224 \text{ mm}$$

$$= 0.224\text{m}$$

$$\therefore \quad BF = BG - FG = 200 - 40 = 160$$

. . . ($\because$ FG = D.

and $$DF = \sqrt{(DB)^2 - (BF)^2} = \sqrt{(300)^2 - (160)^2} = 254 \text{ mr}$$

$$\therefore \tan\alpha = BG/PG = 200 / 224 = 0.893$$

and $$\tan\beta = BF/DF = 160 / 254 = 0.63$$

$$\therefore \quad q = \frac{\tan\beta}{\tan\alpha} = \frac{0.63}{0.893} = 0.705$$

We know that

$$N_2 = \frac{m + \frac{M}{2}(1 + q)}{m} \times \frac{895}{h}$$

$$= \frac{10 + \frac{70}{2}(1 + 0.705)}{10} \times \frac{895}{0.224} = 27\ 840$$

$$\therefore \quad N_2 = 167 \text{ r.p.m. Ans.}$$

2M

Range of speed when friction is equivalent to load of 20 N at the sleeve (i.e. when $F = 20$ N)

Let N_1 = Minimum equilibrium speed, and

N_2 = Maximum equilibrium speed.

We know that when the sleeve moves downwards, the frictional force (F) acts upwards and the minimum equilibrium speed is given by

$$(N_1)^2 = \frac{m.g + \left(\frac{M.g - F}{2}\right)(1 + q)}{m.g} \times \frac{895}{h}$$

$$= \frac{10 \times 9.81 + \left(\frac{70 \times 9.81 - 20}{2}\right)(1 + 0.705)}{10 \times 9.81} \times \frac{895}{0.224} = 27\,144$$

$\therefore \quad N_1 = 164.8$ r.p.m.

We also know that when the sleeve moves upwards, the frictional force (F) acts downwards and the maximum equilibrium speed is given by

$$(N_2)^2 = \frac{m.g + \left(\frac{M.g + F}{2}\right)(1 + q)}{m.g} \times \frac{895}{h}$$

$$= \frac{10 \times 9.81 + \left(\frac{70 \times 9.81 + 20}{2}\right)(1 + 0.705)}{10 \times 9.81} \times \frac{895}{0.224} = 28\,533$$

$\therefore \quad N_2 = 169$ r.p.m.

1M

We know that range of speed

$= N_2 - N_1 = 169 - 164.8 = 4.2$ r.p.m. **Ans.**

2M

(b) **Solution.** Given : $x = 120$ mm $= 0.12$ m ; $y = 100$ mm $= 0.1$ m ; $r = 140$ mm $= 0.14$ m ; $m = 4$ kg ; $N = 300$ r.p.m. or $\omega = 2\pi \times 300/60 = 31.42$ rad/s ; $h_1 = 10$ mm $= 0.01$ m ; $h = 20$ mm $= 0.02$ m

1. ***Minimum equilibrium speed***

Let N_1 = Minimum equilibrium speed,

r_1 = Radius of rotation in the minimum position, *i.e.* when the sleeve moves downward, and

r_2 = Radius of rotation in the maximum position, *i.e.* when the sleeve moves upward.

Since the increase in speed is 4%, therefore maximum speed,

$$N_2 = N + 0.04\,N = 1.04\,N = 1.04 \times 300 = 312 \text{ r.p.m.}$$

or $$\omega_2 = 2\pi \times 312 / 60 = 32.7 \text{ rad/s}$$

We know that lift of the sleeve for the maximum position,

$$h_2 = h - h_1 = 0.02 - 0.01 = 0.01 \text{ m}$$

Now for the minimum position,

$$\frac{h_1}{y} = \frac{r - r_1}{x} \quad \text{or} \quad r_1 = r - h_1 \times \frac{x}{y} = 0.14 - 0.01 \times \frac{0.12}{0.1} = 0.128 \text{ m}$$

Similarly for the maximum position,

$$\frac{h_2}{y} = \frac{r_2 - r}{x} \quad \text{or} \quad r_2 = r + h_2 \times \frac{x}{y} = 0.14 + 0.01 \times \frac{0.12}{0.1} = 0.152 \text{ m}$$

We know that centrifugal force in the mean position,

$$F_C = m.\omega^2.r = 4\,(31.42)^2\,0.14 = 553 \text{ N}$$

Centrifugal force in the minimum position,

$$F_{C1} = m\,(\omega_1)^2\,r_2 = 4\left(\frac{2\pi\,N_1}{60}\right)^2 0.128 = 0.0056\,(N_1)^2 \quad \ldots (i)$$

and centrifugal force in the maximum position,

$$F_{C2} = m.(\omega_2)^2\,r_2 = 4\,(32.7)^2\,0.152 = 650 \text{ N}$$

We know that centrifugal force at any instant,

$$F_C = F_{C1} + (F_{C2} - F_{C1})\left(\frac{r - r_1}{r_2 - r_1}\right)$$

$$553 = F_{C1} + (650 - F_{C1})\left(\frac{0.14 - 0.128}{0.152 - 0.128}\right) = 0.5\,F_{C1} + 325$$

$$\therefore \quad F_{C1} = \frac{553 - 325}{0.5} = 456 \text{ N} \quad \ldots (ii)$$

From equations (*i*) and (*ii*),

$$(N_1)^2 = \frac{456}{0.0056} = 81\,428 \quad \text{or} \quad N_1 = 285.4 \text{ r.p.m. } \textbf{Ans.}$$ 1M

2. ***Spring stiffness***

Let S_1 and S_2 = Spring force at the minimum and maximum position.

Neglecting the effect of obliquity of arms, we have for the minimum position,

$$\frac{M.g + S_1}{2} \times y = F_{C1} \times x \quad \text{or} \quad S_1 = 2\,F_{C1} \times \frac{x}{y} = 2 \times 456 \times \frac{0.12}{0.1} = 1094.4 \text{ N}$$

$$\ldots (\because M = 0)$$

and for the maximum position,

$$\frac{M.g + S_2}{2} \times y = F_{C2} \times x \quad \text{or} \quad S_2 = 2\,F_{C2} \times \frac{x}{y} = 2 \times 650 \times \frac{0.12}{0.1} = 1560 \text{ N}$$

We know that spring stiffness,

$$s = \frac{S_2 - S_1}{h} = \frac{1560 - 1064.4}{20} = 23.28 \text{ N/mm } \textbf{Ans.}$$ 1M

Solution. Given : $BP = BD = 178$ mm ; $PQ = DH = 38$ mm ; $m = 1.15$ kg ; $M = 20$ kg ; $N = 280$ r.p.m. ; $\alpha = \beta = 30°$

First of all, let us find the friction force (F). The equilibrium position of the governor when the lines are at 30° to vertical, is shown in Fig. 18.11. From the figure, we find that radius of rotation,

$$r = BG = BF + FG = BP \times \sin\alpha + FG$$
$$= 178 \sin 30° + 38 = 127 \text{ mm}$$

and height of the governor,

$$h = BG / \tan\alpha$$
$$= 127 / \tan 30° = 220 \text{ mm} = 0.22 \text{ m}$$

We know that

$$N^2 = \frac{m.g + (Mg \pm F)}{m.g} \times \frac{895}{h}$$

$$\ldots (\because \tan\alpha = \tan\beta \text{ or } q = 1)$$

$$(280)^2 = \frac{1.15 \times 9.81 + 20 \times 9.81 \pm F}{1.15 \times 9.81} \times \frac{895}{0.22}$$

or $$\pm F = \frac{(280)^2 \times 1.15 \times 9.81 \times 0.22}{895} - 1.15 \times 9.81 - 20 \times 9.81$$ 2M

$$= 217.5 - 11.3 - 196.2 = 10 \text{ N}$$

We know that radius of rotation when inclination of the arms to the vertical is 45 (*i.e.* when $\alpha = \beta = 45°$),

$$r = BG = BF + FG = BP \times \sin\alpha + FG$$
$$= 178 \sin 45° + 38 = 164 \text{ mm}$$

and height of the governor,

$$h = BG / \tan\alpha = 164 / \tan 45° = 164 \text{ mm} = 0.164 \text{ m}$$

Let N_1 = Minimum speed of rotation, and
N_2 = Maximum speed of rotation.

We know that

$$(N_1)^2 = \frac{m.g + (M.g - F)}{m.g} \times \frac{895}{h}$$

$$= \frac{1.15 \times 9.81 + (20 \times 9.81 - 10)}{1.15 \times 9.81} \times \frac{895}{0.164} = 95\ 382$$

∴ $N_1 = 309$ r.p.m. Ans.

and $$(N_2)^2 = \frac{m.g + (M.g + F)}{m.g} \times \frac{895}{h}$$

$$= \frac{1.15 \times 9.81 + (20 \times 9.81 + 10)}{1.15 \times 9.81} \times \frac{895}{0.164} = 105\ 040$$

$N_2 = 324$ r.p.m. Ans. 2M

4(b) i) Stiffness [illegible] ng and Initial compression of spring at 550 rpm.

Stiffness= [illegible] 54.67 N/m
Initial co [illegible] sion = s_1/s = 0.5847

2.5

ii) Radius at [illegible] masses rotate when the equilibrium speed is 525 rpm

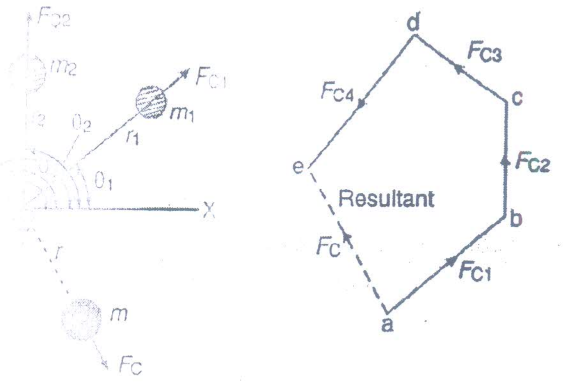
R = 0.1 [illegible]

2.5

4(c) **Balancing o [illegible] es rotating in same plane:**

Consider any [illegible] of masses (say four) of magnitude m_1, m_2, m_3 and m_4 at distances of r_1, r_2, r_3 and r_4 [illegible] of the rotating shaft. Let $\theta_1, \theta_2, \theta_3$ and θ_4 be the angles of these masses with the [illegible] OX, as shown in Fig. 21.4 (*a*). Let these masses rotate about an axis through *O* a [illegible] the plane of paper, with a constant angular velocity of ω rad/s.

The [illegible] sition of the balancing mass may be found out analytically or graphically [illegible]



[illegible] e diagram. (*b*) Vector diagram.

2.5

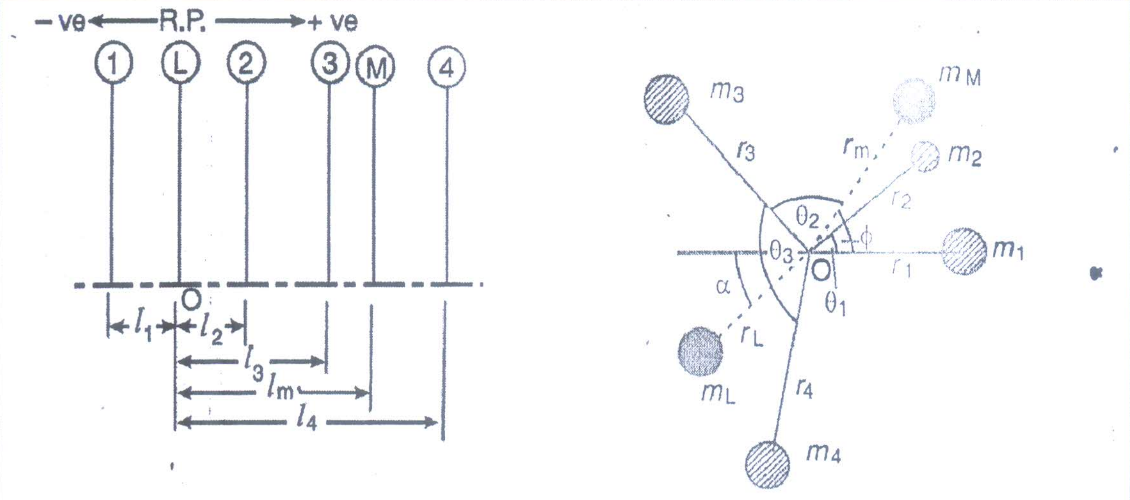
The magnitude [illegible] n of the balancing mass may also be obtained graphically as discussed bel [illegible]

1. First [illegible] e diagram with the positions of the several masses, as shown in Fig. 2 [illegible]
2. Find [illegible] force (or product of the mass and radius of rotation) exerted by each [illegible] shaft.
3. Now [illegible] with the obtained centrifugal forces (or the product of the masse [illegible]), such that *ab* represents the centrifugal force exerted by the [illegible] gnitude and direction to some suitable scale. Similarly, draw *bc*, [illegible] centrifugal forces of other masses m_2, m_3 and m_4 (or $m_2.r_2$, $m_3.r_3$ [illegible]
4. Now [illegible] of forces, the closing side *ae* represents the resultant force in ma [illegible] s shown in Fig. 21.4 (*b*).
5. Th [illegible] n, equal to the resultant force, but in ***opposite direction.***
6. N [illegible] e of the balancing mass (*m*) at a given radius of rotation (*r*), su [illegible]

Resultant centrifugal force

or Resultant of $m_1.r_1$, $m_2.r_2$, $m_3.r_3$ and $m_4.r_4$

Balancing of several masses rotating in Different plane:



(*a*) Position of planes of the masses. (*b*) Angular position of the masses.

1. Take one of the planes, say L as the reference plane (*R.P.*). The distances of all the other planes to the left of the reference plane may be regarded as ***negative***, and those to the right as ***positive***.
2. Tabulate the data as shown in Table 21.1. The planes are tabulated in the same order in which they occur, reading from left to right.

Plane (1)	*Mass (m)* (2)	*Radius(r)* (3)	*Cent.force* $\div \omega^2$ *(m.r)* (4)	*Distance from Plane L (l)* (5)	*Couple* $\div \omega^2$. *(m.r.l)* (6)
1	m_1	r_1	$m_1.r_1$	$-l_1$	$-m_1.r_1.l_1$
L(R.P.)	m_L	r_L	$m_L.r_L$	0	0
2	m_2	r_2	$m_2.r_2$	l_2	$m_2.r_2.l_2$
3	m_3	r_3	$m_3.r_3$	l_3	$m_3.r_3.l_3$
M	m_M	r_M	$m_M.r_M$	l_M	$m_M.r_M.l_M$
4	m_4	r_4	$m_4.r_4$	l_4	$m_4.r_4.l_4$

3. A couple may be represented by a vector drawn perpendicular to the plane of the couple. The couple C_1 introduced by transferring m_1 to the reference plane through O is proportional to $m_1.r_1.l_1$ and acts in a plane through Om_1 and perpendicular to the paper. The vector representing this couple is drawn in the plane of the paper and perpendicular to Om_1 as shown by OC_1 in Fig. 21.7 (*c*). Similarly, the vectors OC_2, OC_3 and OC_4 are drawn perpendicular to Om_2, Om_3 and Om_4 respectively and in the plane of the paper.
4. The couple vectors as discussed above, are turned counter clockwise through a right angle for convenience of drawing as shown in Fig. 21.7 (*d*). We see that their relative positions remains unaffected. Now the vectors OC_2, OC_3 and OC_4 are parallel and in the same direction as Om_2, Om_3 and Om_4, while the vector OC_1 is parallel to Om_1 but in opposite direction. Hence the ***couple vectors are drawn radially outwards for the masses on one side of the reference plane and radially inward for the masses on the other side of the reference plane.***

5. Now [illegible] lygon as shown in Fig. 21.7 (*e*). The vector $d'o'$ represents the balan[illegible] balanced couple C_M is proportional to $m_M.r_M.l_M$, therefore

$$C_M \ [illegible] \ l_M = \text{vector } d'o' \quad \text{or} \quad m_M = \frac{\text{vector } d'o'}{r_M \cdot l_M}$$

From this [illegible] value of the balancing mass m_M in the plane *M* may be obtained, and th[illegible] on ϕ of this mass may be measured from Fig. 21.7 (*b*).

6. Now [illegible] on as shown in Fig. 21.7 (*f*). The vector *eo* (in the direction from [illegible] balanced force. Since the balanced force is proportional to $m_L.r_L$ [illegible]

$$m_L \ [illegible] \ eo \quad \text{or} \quad m_L = \frac{\text{vector } eo}{r_L}$$

From th[illegible] value of the balancing mass m_L in the plane *L* may be obtained and the an[illegible] s mass with the [illegible]rizontal may be measured from Fig. 21.7 (*b*).

Signature of C[illegible] **Signat[illegible] Module Coordinator** K. Rana **Signature of HOD/ME**

Signat[illegible] **[illegible]mic Coordinator** **Signature of Principal**

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109
II SESSIONAL TEST QUESTION PAPER 2018 – 19 ODD SEMESTER

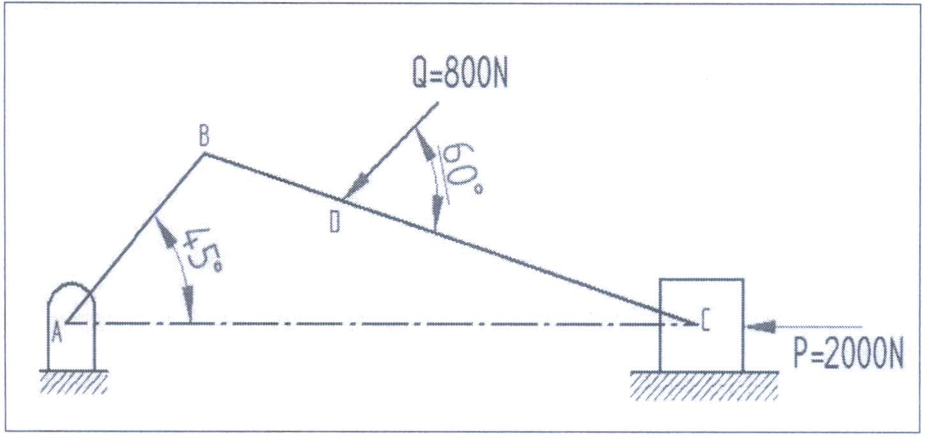
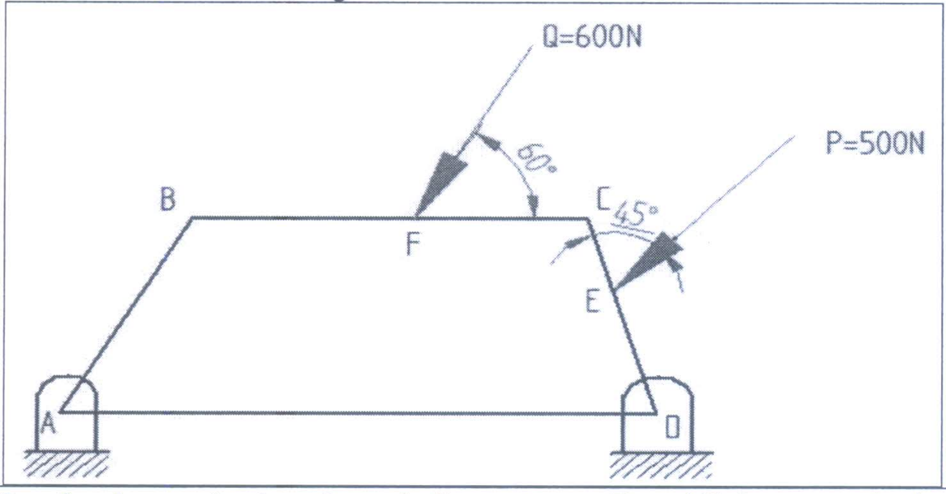
SET – B

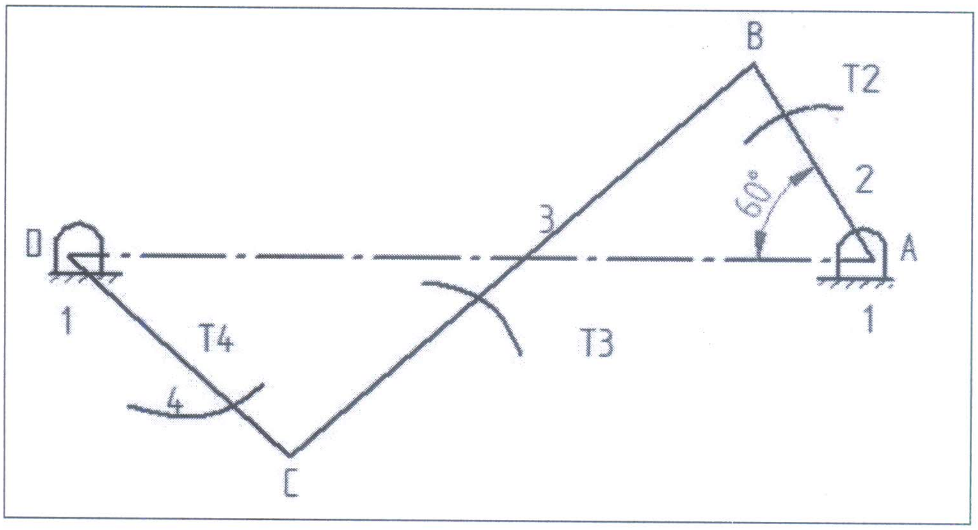
USN

Degree : **B.E**
Branch : **Mechanical Engineering**
Course Title : **DYNAMICS OF MACHINERY**
Duration : **90 Minutes**
Semester : **V A & B**
Course Code : **15ME52**
Date : **25-10-2018**
Max Marks : **30**

Note: Answer ONE full question from each part.

Q No.	Question	Marks	CO mapping	K-Level
	PART-A			
1(a)	A shaft carries four masses A, B, C and D of magnitude 200 kg, 300 kg,400 kg and 200 kg respectively and revolving at radii 80 mm, 70 mm, 60 mm and 80 mm in planes measured from A at 300 mm, 400 mm and 700 mm. The angles between the cranks measured anticlockwise are A to B 45°, B to C 70° and C to D 120°. The balancing masses are to be placed in planes X and Y. The distance between the planes A and X is 100 mm, between X and Y is 400mm and between Y and D is 200 mm. If the balancing masses revolve at a radius of 100 mm, **find** their magnitudes and angular positions.	5	CO2	Apply (K3)
(b)	A shaft carries four masses in parallel planes A, B, C and D in this order along its length. The masses at B and C are 18 kg and 12.5 kg respectively, and each has an eccentricity of 60 mm. The masses at A and D have an eccentricity of 80 mm. The angle between the masses at B and C is 100° and that between the masses at B and A is 190°, both being measured in the same direction. The axial distance between the planes A and B is 100 mm and that between B and C is 200 mm. If the shaft is in complete dynamic balance, **Determine :** **1.** The magnitude of the masses at A and D **2.** The distance between planes A and D **3.** The angular position of the mass at D.	5	CO2	Apply (K3)
(c)	A shaft is supported in bearings 1.8 m apart and projects 0.45 m beyond bearings at each end. The shaft carries three pulleys one at each end and one at the middle of its length. The mass of end pulleys is 48 kg and 20 kg and their centre of gravity are 15 mm and 12.5 mm respectively from the shaft axis. The centre pulley has a mass of 56 kg and its centre of gravity is 15 mm from the shaft axis. If the pulleys are arranged so as to give static balance, **Determine :** **1.** Relative angular positions of the pulleys **2.** Dynamic forces produced on the bearings when the shaft rotates at 300 r.p.m.	5	CO2	Apply (K3)
	OR			
2(a)	A shaft has three eccentrics, each 75 mm diameter and 25 mm thick, machined in one piece with the shaft. The central planes of the eccentric are 60 mm apart. The distance of the centers from the axis of rotation are 12 mm, 18 mm and 12 mm and their angular positions are 120° apart. The density of metal is 7000 kg/m^3. Find the amount of out-of-balance force and couple at 600 r.p.m. If the shaft is balanced by adding two masses at a radius 75 mm and at distances of 100 mm from the central plane of the middle eccentric, **find** the amount of the masses and their angular positions.	5	CO2	Apply (K3)

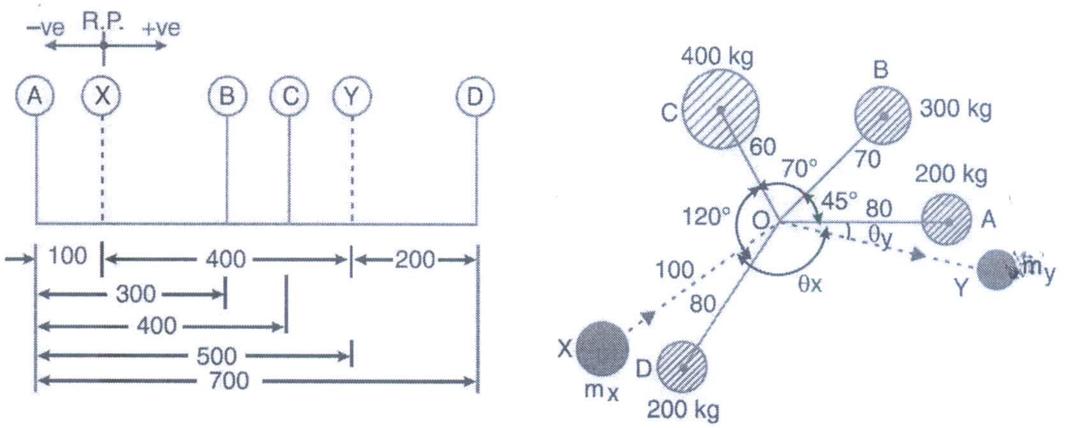
(b)	A, B, C and D are four masses carried by a rotating shaft at radii 100,125, 200 and 150 mm respectively. The planes in which the masses revolve are spaced 600 mm apart and the mass of B, C and D are 10 kg, 5 kg, and 4 kg respectively. **Find** the required mass A and the relative angular settings of the four masses so that the shaft shall be in complete balance.	5	CO2	Apply (K3)
(c)	Three masses 10kg, 12kg and 8kg are revolving at a radii of 6cm, 7cm and 8cm in three planes A, B and C respectively of the shaft. Planes B and C are at a distance of 0.5m from A and on either side of A. Three masses are placed in such a way that they are statically balanced. **Find** the unbalanced couple in a plane mid way between A and B if the shaft revolves at 1000rpm.	5	CO2	Apply (K3)
PART-B				
3(a)	**Explain** the Condition of equilibrium for a body subjected to two forces, three forces and two forces and a torque.	5	CO3	Understand (K2)
(b)	For the slider crank mechanism shown in figure, **Determine** the input torque T_2 on the link AB for the static equilibrium of mechanism. AB=300mm, BC=600mm, BD=200mm.  	5	CO3	Apply (K3)
(c)	**Establish** the differential equation of damped free vibration	5	CO5	Analyze (K4)
OR				
4(a)	A four mechanism under the action of two external forces is as shown in the figure. **Determine** the torque to be applied on link AB for static equilibrium. The dimensions of the links are AB=50mm, BC=66mm, CD=55mm, CE=25mm, CF=30mm, angle BAD=60^0 and AD=100mm.  	5	CO3	Apply (K3)
(b)	In a four bar mechanism shown in figure, torque T_3 and T_4 have magnitude of 3000N-m and 2000N-m respectively. Take AD=800mm, AB=300mm, BC=700mm and CD=400mm. For the static equilibrium of mechanism, **find** the required input torque on crank.	5	CO3	Apply (K3)

				
(c)	Define Damping and **explain** different types of damping	**5**	**CO5**	**Understand (K2)**

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109
II SESSIONAL TEST QUESTION PAPER 2018 – 19 ODD SEMESTER

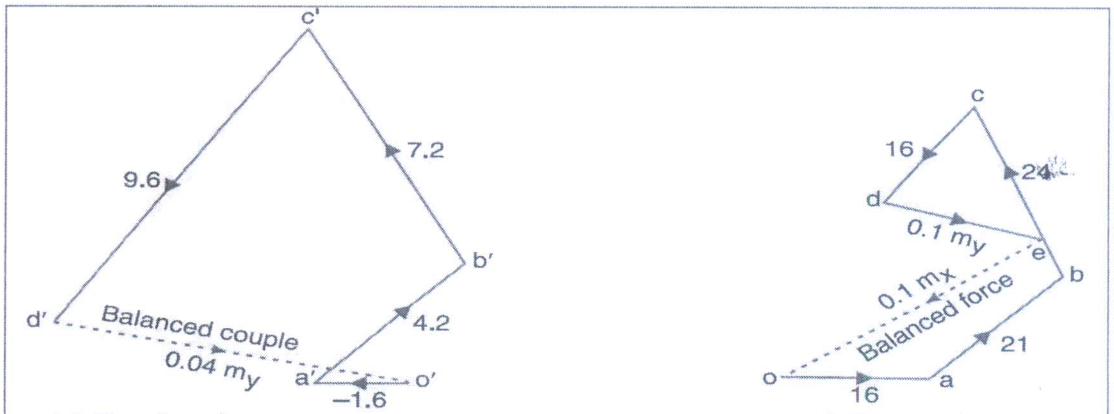
SCHEME AND SOLUTION

Degree	:	**B.E**	**Semester**	:	**V A & B**
Branch	:	**Mechanical Engineering**	**Course Code**	:	**15ME52**
Course Title	:	**DYNAMICS OF MACHINERY**	**Max Marks**	:	**30**

<table>
<tr><th>Q.NO.</th><th>POINTS</th><th>MARKS</th></tr>
<tr><td>1(a)</td><td>


All dimensions in mm.

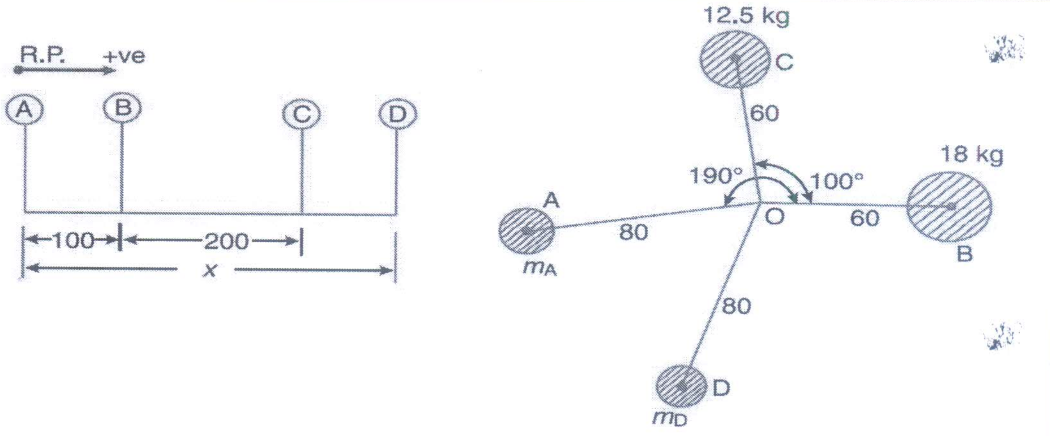
(*a*) Position of planes. (*b*) Angular position of masses.
</td><td>2M</td></tr>
<tr><td></td><td>
<table>
<tr><th><i>Plane</i>

(1)</th><th><i>Mass (m)</i>
kg
(2)</th><th><i>Radius (r)</i>
m
(3)</th><th><i>Cent.force</i> ÷ ω^2
(m.r) kg-m
(4)</th><th><i>Distance from Plane x(l) m</i>
(5)</th><th><i>Couple</i> ÷ ω^2
(m.r.l) kg-m^2
(6)</th></tr>
<tr><td>A</td><td>200</td><td>0.08</td><td>16</td><td>– 0.1</td><td>– 1.6</td></tr>
<tr><td>X(R.P.)</td><td>m_X</td><td>0.1</td><td>0.1 m_X</td><td>0</td><td>0</td></tr>
<tr><td>B</td><td>300</td><td>0.07</td><td>21</td><td>0.2</td><td>4.2</td></tr>
<tr><td>C</td><td>400</td><td>0.06</td><td>24</td><td>0.3</td><td>7.2</td></tr>
<tr><td>Y</td><td>m_Y</td><td>0.1</td><td>0.1 m_Y</td><td>0.4</td><td>0.04 m_Y</td></tr>
<tr><td>D</td><td>200</td><td>0.08</td><td>16</td><td>0.6</td><td>9.6</td></tr>
</table>
</td><td>1M</td></tr>
<tr><td></td><td>


(*c*) Couple polygon. (*d*) Force polygon.
</td><td>2M</td></tr>
</table>

M_y= 182.5 kg, Angular position of Y = 12^0
M_x= 355 kg, Angular position of X = 145^0

1(b)



All dimensions in mm.

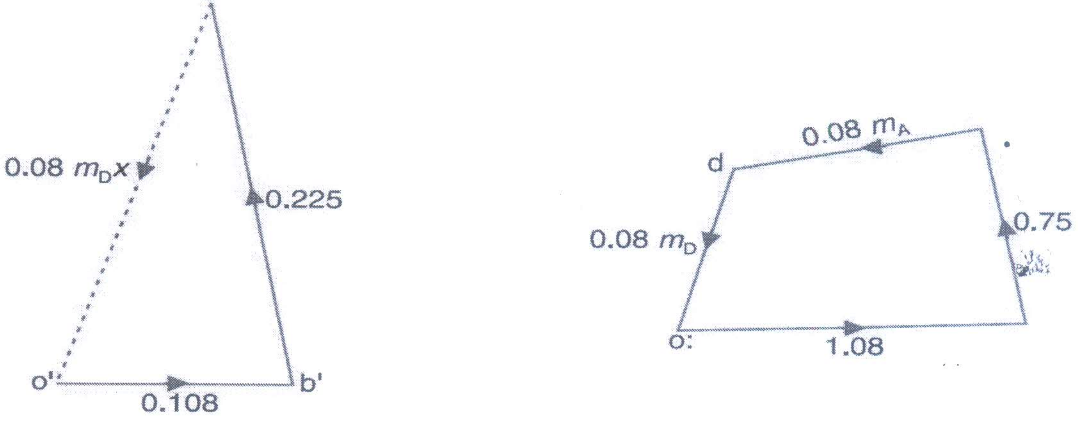
(*a*) Position of planes.

(*b*) Angular position of masses.

2M

Plane (1)	Mass (m) kg (2)	Eccentricity (r) m (3)	Cent. force ÷ ω^2 (m.r) kg-m (4)	Distance from plane A(l)m (5)	Couple ÷ ω^2 (m.r.l) kg-m^2 (6)
A (R.P.)	m_A	0.08	0.08 m_A	0	0
B	18	0.06	1.08	0.1	0.108
C	12.5	0.06	0.75	0.3	0.225
D	m_D	0.08	0.08 m_D	x	0.08 m_D . x

1M



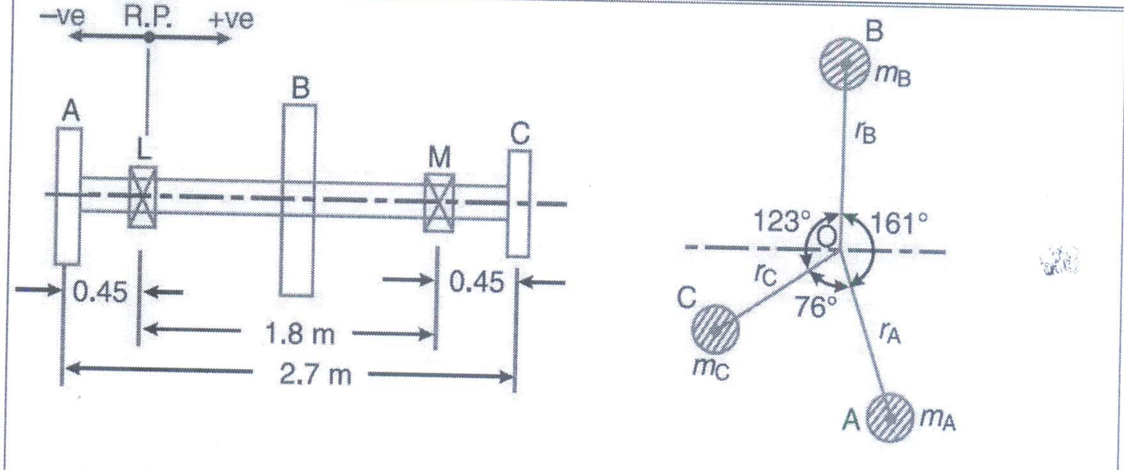
(c) Couple polygon.

(*d*) Force polygon.

2M

Mass of A and D = 9.625kg & 8.125kg
Distance between planes A & D = 361.5mm
Angular position of mass D = 251^0

1(c)



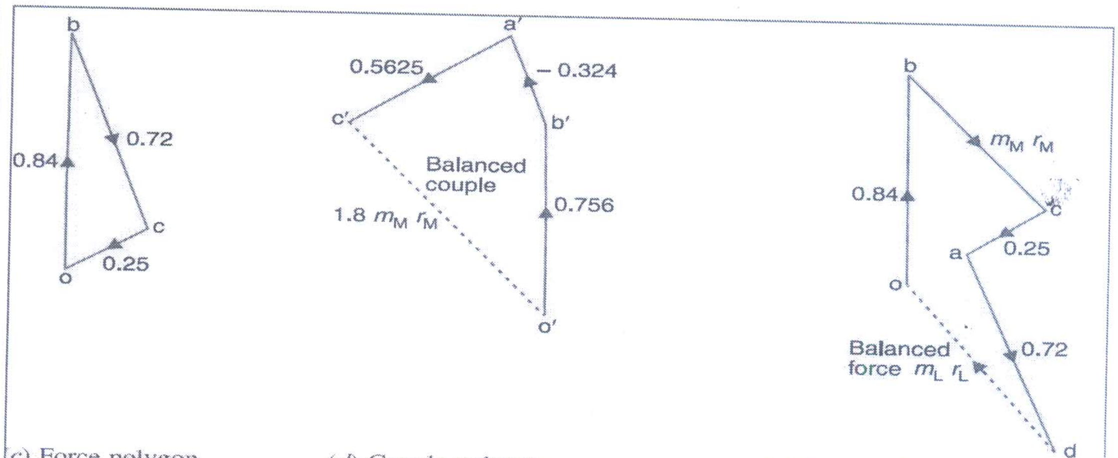
(*a*) Position of shaft and pulleys.

(*b*) Angular position of pulleys.

2M

Plane *(1)*	*Mass* *(m) kg* *(2)*	*Radius* *(r) m* *(3)*	*Cent. force* $\div \omega^2$ *(m.r) kg-m* *(4)*	*Distance from* *plane L(l)m* *(5)*	*Couple* $\div \omega^2$ *(m.r.l) kg-m²* *(6)*
A	48	0.015	0.72	– 0.45	– 0.324
L(R.P)	m_L	r_L	$m_L.r_L$	0	0
B	56	0.015	0.84	0.9	0.756
M	m_M	r_M	$m_M.r_M$	1.8	1.8 $m_M.r_M$
C	20	0.0125	0.25	2.25	0.5625

1M



(*c*) Force polygon.

(*d*) Couple polygon.

(*e*) Force polygon.

2M

Angle between pulley B & A= 161^0 , Angle between pulley A & C= 76^0
Angle between pulley C & B= 123^0.
Dynamic Force on bearing L and M= 533N.

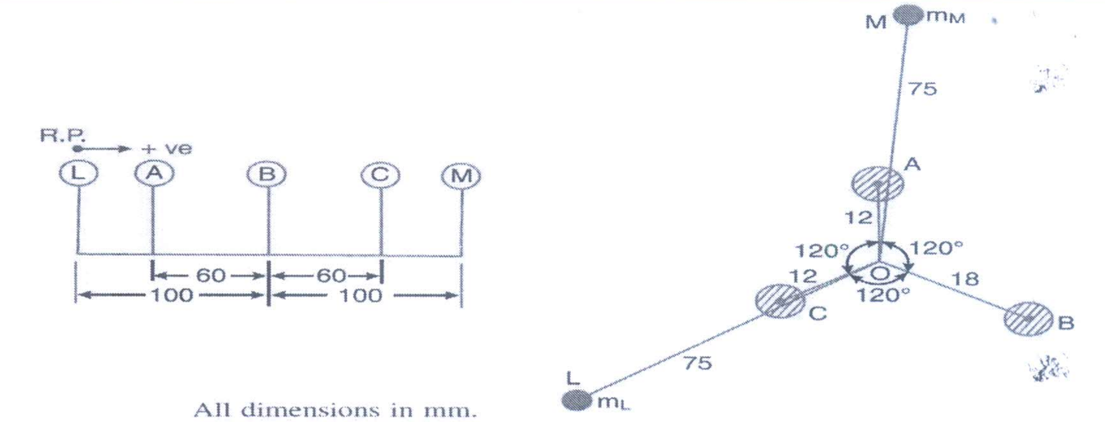
OR

2(a)

$$m_A = m_B = m_C = \text{Volume} \times \text{Density} = \frac{\pi}{4} \times D^2 \times t \times \rho$$

$$= \frac{\pi}{4}(0.075)^2(0.025)7000 = 0.77 \text{ kg}$$

1M



All dimensions in mm.

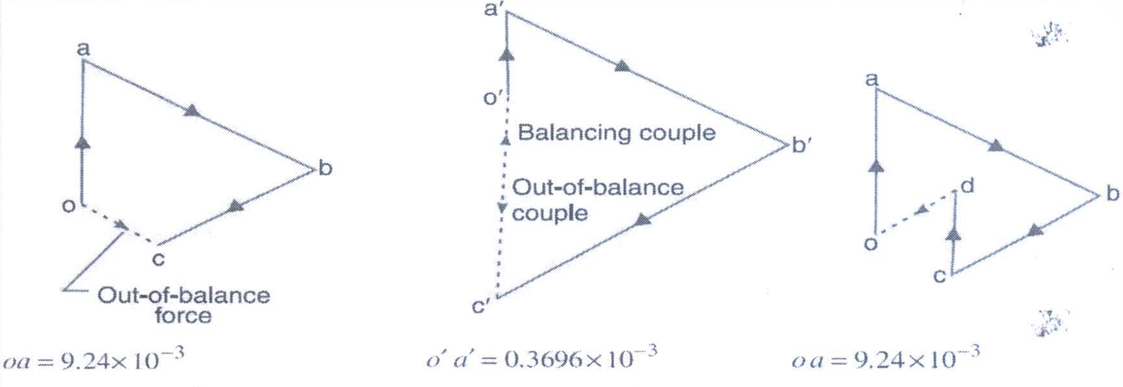
(*a*) Position of planes.

(*b*) Angular position of masses.

1M

Plane (1)	Mass (m) kg (2)	Radius (r) m (3)	Cent. force $\div \omega^2$ (m.r) kg-m (4)	Distance from plane L.(l)m (5)	Couple $\div \omega^2$ (m.r.l) kg-m^2 (6)
L (R.P.)	m_L	0.075	$75 \times 10^{-3}\ m_L$	0	0
A	0.77	0.012	9.24×10^{-3}	0.04	0.3696×10^{-3}
B	0.77	0.018	13.86×10^{-3}	0.1	1.386×10^{-3}
C	0.77	0.012	9.24×10^{-3}	0.16	1.4784×10^{-3}
M	m_M	0.075	$75 \times 10^{-3}\ m_M$	0.20	$15 \times 10^{-3}\ m_M$

1M



$oa = 9.24 \times 10^{-3}$

$ab = 13.86 \times 10^{-3}$

$bc = 9.24 \times 10^{-3}$

(*c*) Force polygon.

$o'a' = 0.3696 \times 10^{-3}$

$a'b' = 1.386 \times 10^{-3}$

$b'c' = 1.4784 \times 10^{-3}$

(*d*) Couple polygon.

$oa = 9.24 \times 10^{-3}$

$ab = 13.86 \times 10^{-3}$

$bc = 9.24 \times 10^{-3}$

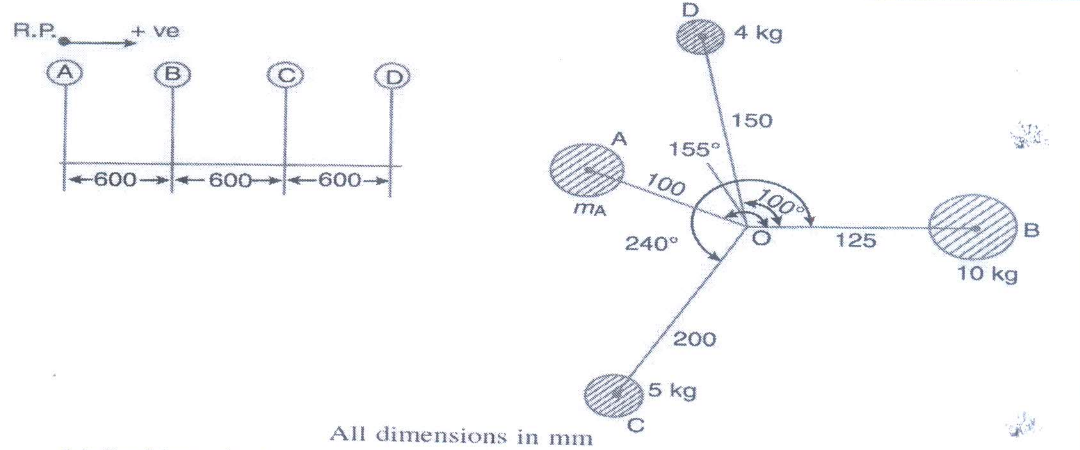
$cd = 75 \times 10^{-3} m_M$

(*e*) Force polygon.

2M

Out of balance force & Couple= 18.76N & 4.34 N-m, Amount of Balancing mass L & M= 0.073 & 0.0693 kg. Angular position of L= 124^0.

2(b)



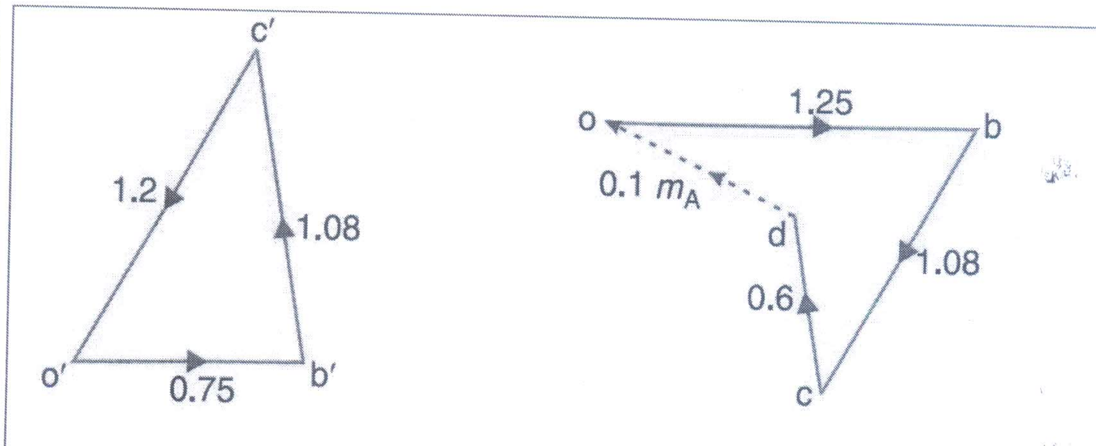
All dimensions in mm

(*a*) Position of planes. (*b*) Angular position of masses.

2M

Plane (1)	Mass (m) kg (2)	Radius (r) m (3)	Cent. Force $\div \omega^2$ (m.r)kg-m (4)	Distance from plane A (l)m (5)	Couple $\div \omega^2$ (m.r.l) kg-m^2 (6)
A(R.P.)	m_A	0.1	0.1 m_A	0	0
B	10	0.125	1.25	0.6	0.75
C	5	0.2	1	1.2	1.2
D	4	0.15	0.6	1.8	1.08

1M

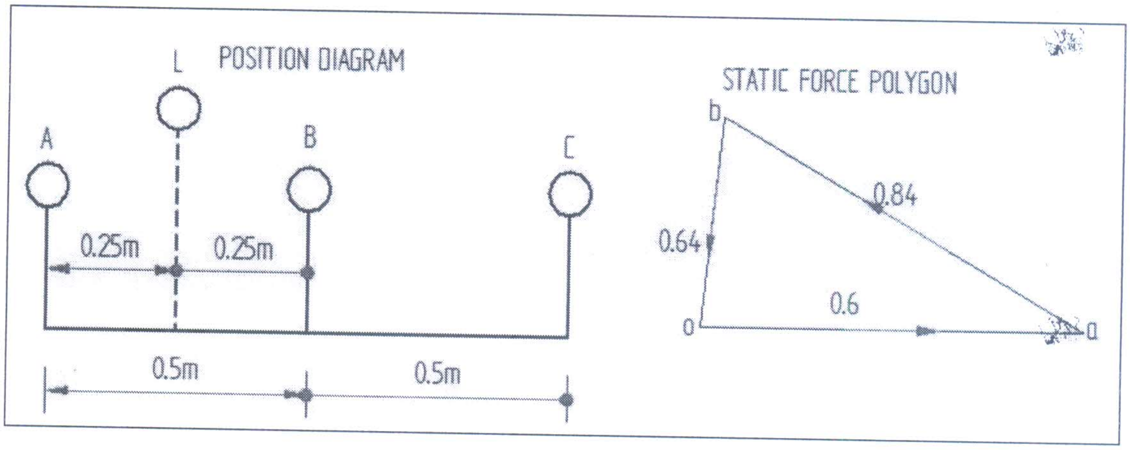


(*c*) Couple polygon. (*d*) Force polygon.

2M

Mass of A= 7kg, Angular position of A = 155^0.

2(c)

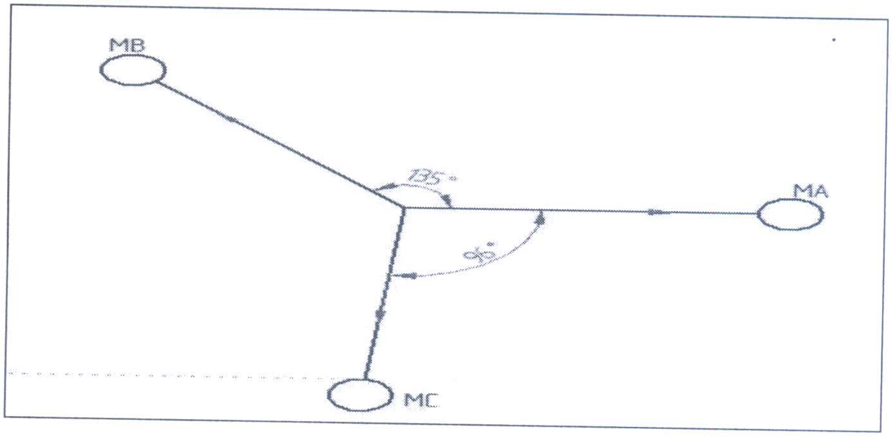


2M

PLANE	MASS(m) Kg	RADIUS(r) m	FORCE (mr) N	DISTANCE FROM RP	COUPLE (mrl) N-m
B	12	0.07	0.84	-0.25	-0.21
L	M_L	R_L	$M_L R_L$	0	0
A	10	0.06	0.6	0.25	0.15
C	08	0.08	0.64	0.75	0.48

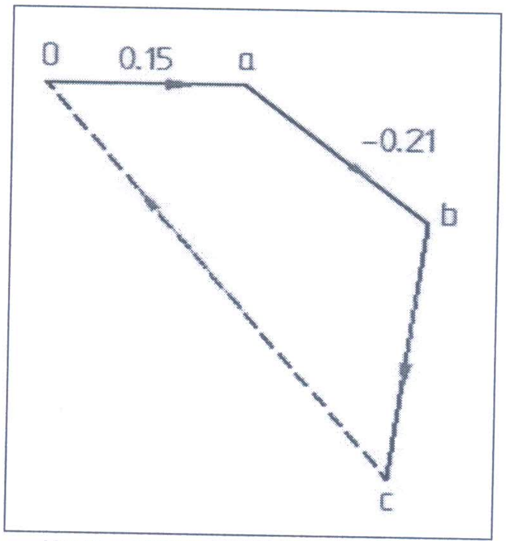
1M

SPACE DIAGRAM:



2M

COUPLE POLYGON:



UN BALANCED COUPLE= 7347.3 N-m

PART-B

3(a)

1.2 BODIES IN EQUILIBRIUM

1M

Consider bodies or links in equilibrium under specific system of forces.

(i) Equilibrium of two force system.

(ii) Equilibrium of three force system.

(iii) Equilibrium of four force system.

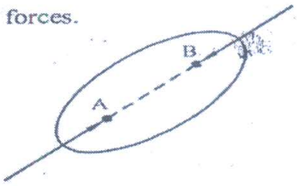


Fig. 1.1 2-F system

1) Equilibrium of two force member:

A member subjected to two forces is in equilibrium if only if

(i) Two forces must be equal in magnitude but with opposite sense.

(ii) Two forces must be collinear i.e., act along the same line.

A body acted upon by two forces F_1 and F_2 is shown in figure 1.1.

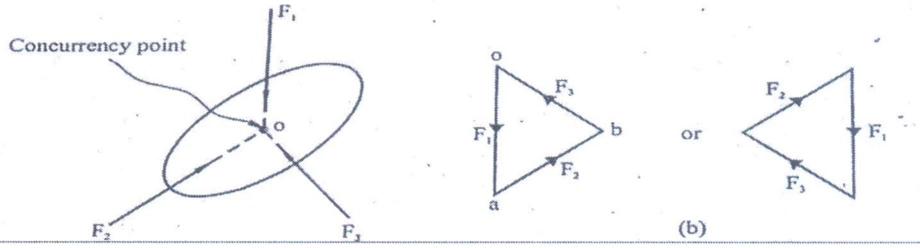
2) Equilibrium of three force member:

A member subjected to three forces is in equilibrium if only if

(i) The resultant of the three forces is zero.

(ii) The forces are concurrent i.e., the lines of action of the forces intersect at common point O.

2M



1.3 MEMBER WITH TWO FORCES AND A TORQUE

A member subjected to two forces and an applied torque will be in equilibrium if

(i) Two forces are equal in magnitude, parallel in direction and opposite in sense.

(ii) Two forces constitute a couple which is equal and opposite to the applied torque.

2M

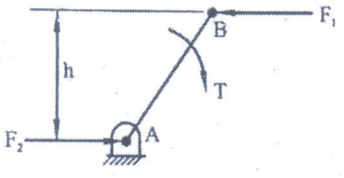


Fig. 1.5

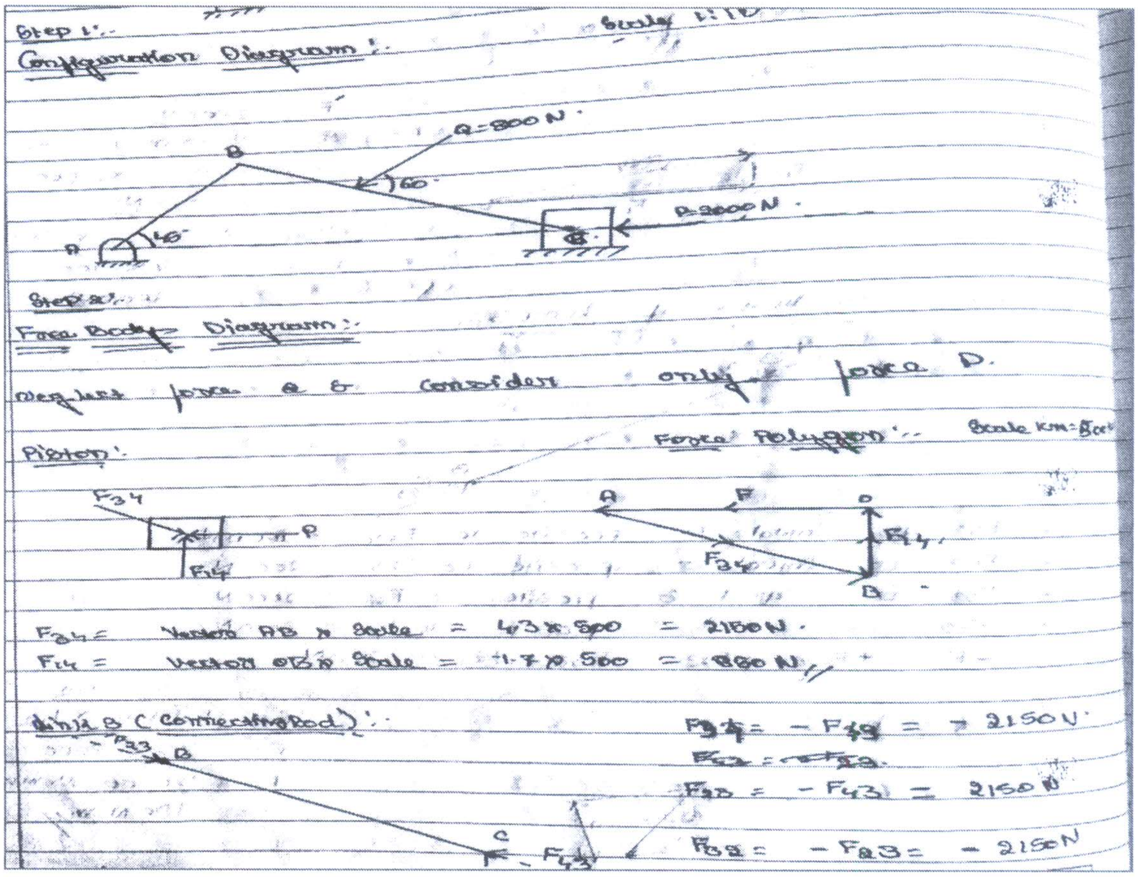
A body subjected to two equal and opposite forces F_1 and F_2 and an applied torque T is shown in figure 1.5. For equilibrium, we have

$$F_1 = -F_2 \text{ (for equilibrium)}$$

$$T = F_1 \times h = F_2 \times h$$

Where h = Perpendicular distance between F_1 and F_2.

3(b)



Step 1:-   Scale 1:10

Configuration Diagram:

1M

Step 2:-

Free Body Diagram:

Neglect force Q & consider only force P.

Piston: Force Polygon:-   Scale 1cm=5

F_{34} = Vector AB x Scale = 4.3 x 500 = 2150N.

F_{14} = Vector OB x Scale = 1.7 x 500 = 850 N//

2M

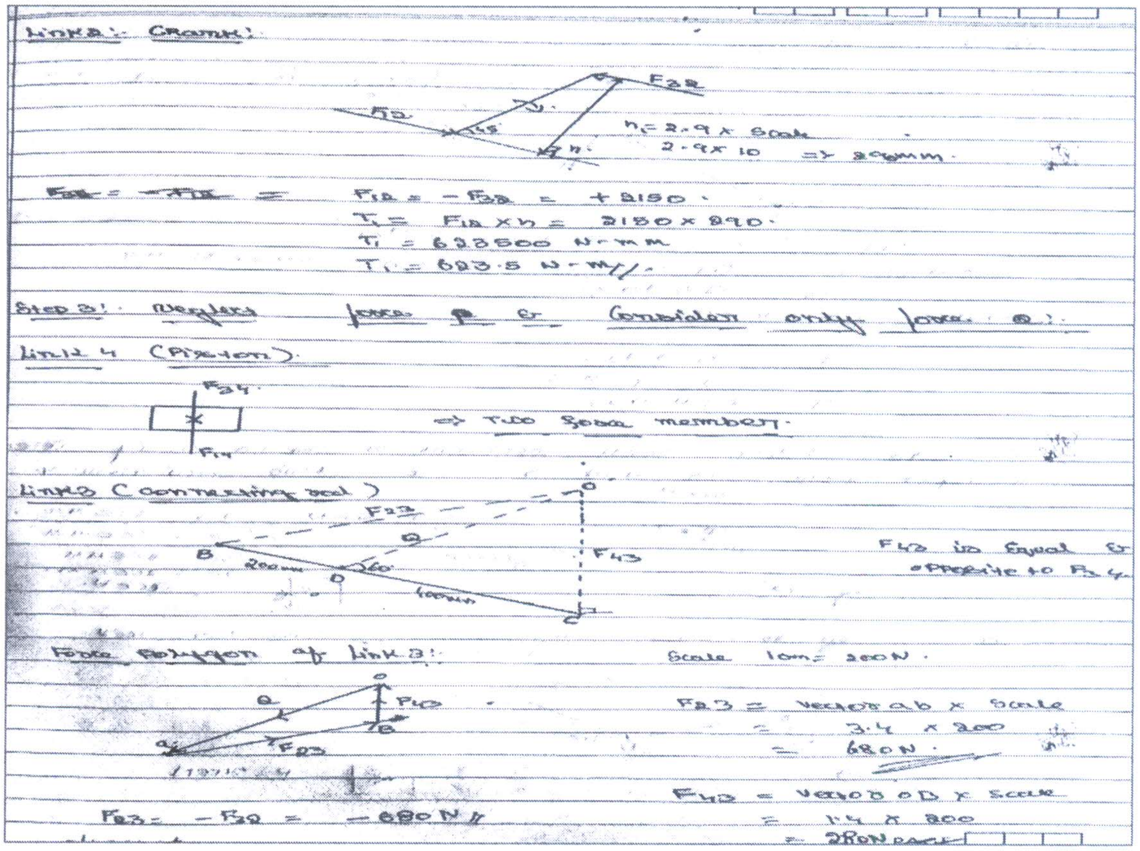
Link 3 (Connecting Rod):

F_{43} = − F_{34} = − 2150 N.

~~F_{23} = − F_{43}.~~

F_{23} = − F_{43} = 2150 N

F_{32} = − F_{23} = − 2150N



Link 2:- Crank:

h = 2.9 x Scale

2.9 x 10 => 290mm.

~~F_{21} = −F_{12}~~ = F_{12} = − F_{32} = + 2150.

T_1 = F_{12} x h = 2150 x 290.

T_1 = 623500 N-mm

T_1 = 623.5 N-m//.

Step 3: Neglect force P & Consider only force Q:

Link 4 (Piston).

=> Two force member.

Link 3 (Connecting rod)

F_{43} is Equal & opposite to F_{34}.

Force Polygon of link 3:   Scale 1cm= 200N.

F_{23} = Vector ab x Scale

= 3.4 x 200

= 680N.

F_{43} = Vector OB x Scale

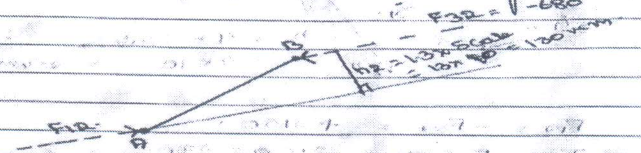
= 1.4 x 200

= 280N

F_{32} = − F_{23} = − 680 N //

Link 2 (crank):

Link 2 is subjected to two forces, F_{32} & F_{12} & a Torque T_2



$F_{12} = -F_{32} = -(-680) = 680$ N//.

Torque T_2 = $F_{12} \times h_2$ = 680 x 130 = 88400 N-mm.

T_2 = 88.4 Nm//.

Total input torque:

$T = T_1 + T_2 =$

623.5 + 88.5.

T = 712 N-m//.

2M

3(c)

Consider a mathematical model of spring-mass-dashpot system which is supported elastically by a spring and a damper shown in below figure 5.5(a). Let k be the stiffness of the spring, m is the mass of the body and c be the damping co-efficient. Let the mass be displaced by a small amount x downwards. The external forces acting on the body are

a. The spring force kx acting in the upward direction.

b. The damping force $c\dot{x}$ acting in the upward direction.

Applying Newton's II Law

$$m\ddot{x} = \Sigma F_x$$

$$m\ddot{x} = -kx - c\dot{x}$$

$$m\ddot{x} + c\dot{x} + kx = 0 \quad \text{------(1)}$$

1M

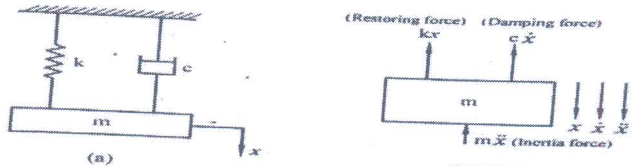


Fig.5.5 Damped-free vibration model

The equation (1) is a homogeneous linear differential equation of the second order and assuming a solution is of the form

$$x = e^{st}$$

$$\frac{dx}{dt} = \dot{x} = se^{st}$$

$$\frac{d^2x}{dt^2} = \ddot{x} = s^2e^{st}$$

Substituting these expressions in equation (1), we get

$$ms^2e^{st} + cse^{st} + ke^{st} = 0$$

$$(ms^2 + cs + k)e^{st} = 0$$

$$ms^2 + cs + k = 0 \quad \text{------(2)}$$

The above equation is called auxillary or charactersic equation of the system.

$$s^2 + \left(\frac{c}{m}\right)s + \left(\frac{k}{m}\right) = 0$$

2M

This equation is quadratic in s and its two roots are given by

$$s_{1,2} = \frac{-c}{2m} \pm \sqrt{\left(\frac{c}{2m}\right)^2 - \frac{k}{m}} \quad \text{----(3)}$$

These two roots give two solutions to equation (1)

$$x_1 = c_1 e^{s_1 t}\ ;\ x_2 = c_2 e^{s_2 t}$$

Thus the general solution of equation is given by combination of two solutions x_1 & x_2

$$x = c_1 e^{s_1 t} + c_2 e^{s_2 t}$$

2M

$$x = c_1 e^{\left\{\frac{-c}{2m} + \sqrt{\left(\frac{c}{2m}\right)^2 - \frac{k}{m}}\right\}t} + c_2 e^{\left\{\frac{-c}{2m} - \sqrt{\left(\frac{c}{2m}\right)^2 - \frac{k}{m}}\right\}t} \quad \text{----(4)}$$

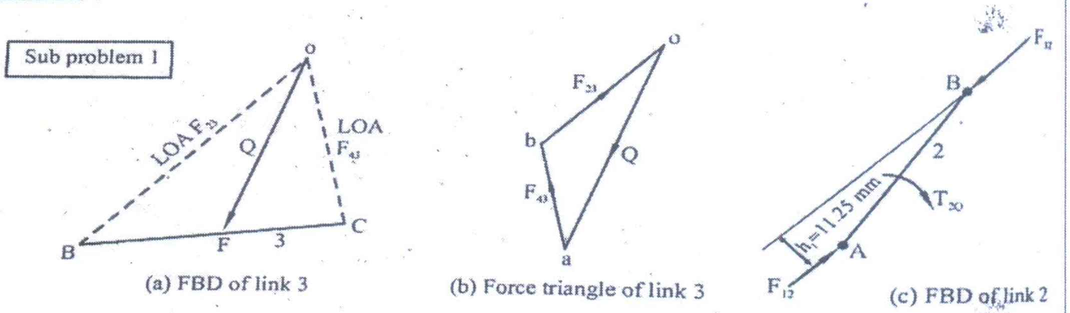
Where c_1 and c_2 are arbitary constants and can be determined from the initial conditions.

Critical damping co-efficient and damping ratio :

OR

4(a)

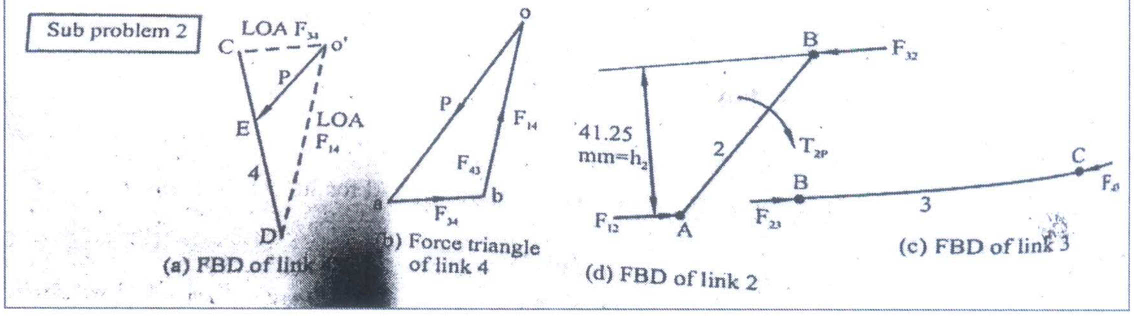
Solution :



(a) FBD of link 3 (b) Force triangle of link 3 (c) FBD of link 2

Fig. 1.38

2M



(a) FBD of link 4 (b) Force triangle of link 4 (d) FBD of link 2 (c) FBD of link 3

2M

Steps involved:

1. Draw the configuration diagram of mechanism as shown in figure 1.37 with suitable scale.
2. Consider the effect of force Q neglecting force P and find torque T_{2Q} (torque on link 2 by considering force Q).
   (i) Consider link 3. Draw the *FBD* of link 3 and find the line of action of F_{23} and F_{43} (Fig 1.38(a)).
   (ii) Draw the force triangle for link 2 as shown in fig 1.38(b) with suitable scale and then determine the magnitude of F_{43} and F_{23}. On measurement,

1M

$$F_{43} = 300 \text{ N} = -F_{34}$$
$$F_{23} = 384 \text{ N} = -F_{32} = F_{12}$$

   (iii) Draw the *FBD* of link 2 as shown in fig 1.38(c) and find T_{2Q}.

$$T_{2Q} = F_{32} \times h_1 = 384 \times 11.25 = 4320 \text{ N-m (clockwise)}$$

3. Now consider the effect of force P neglecting force Q and find torque T_{2P} (torque on link 2 by considering force P).
   (i) Consider link 4. Draw the *FBD* of link 4 and find the line of action of F_{34} and F_{14} (Fig. 1.39(a)).
   (ii) Draw the force triangle for link 4 as shown in fig 1.39(b) with suitable scale and then find the magnitude of F_{34} and F_{14}. On measurement,

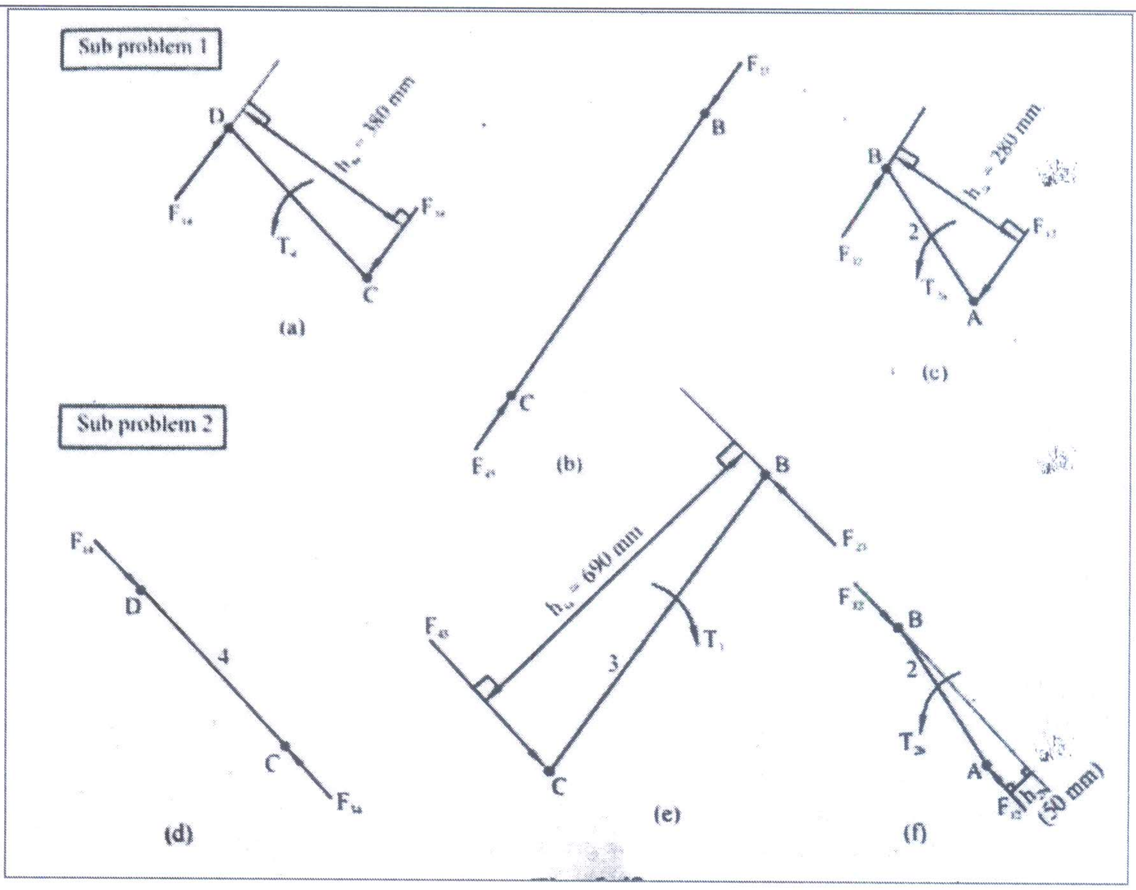
$$F_{34} = 190 \text{ N} = -F_{43} = F_{23} = -F_{32}$$
$$F_{14} = 400 \text{ N}$$

   (iii) Draw the *FBD* of link 3 as shown in figure 1.39(c).
   (iv) Draw the *FBD* of link 2 as shown in figure 1.39(d) and find T_{2P}.

$$T_{2P} = F_{32} \times h_2 = 190 \times 41.25 = 7837.5 \text{ N-mm (clockwise)}$$

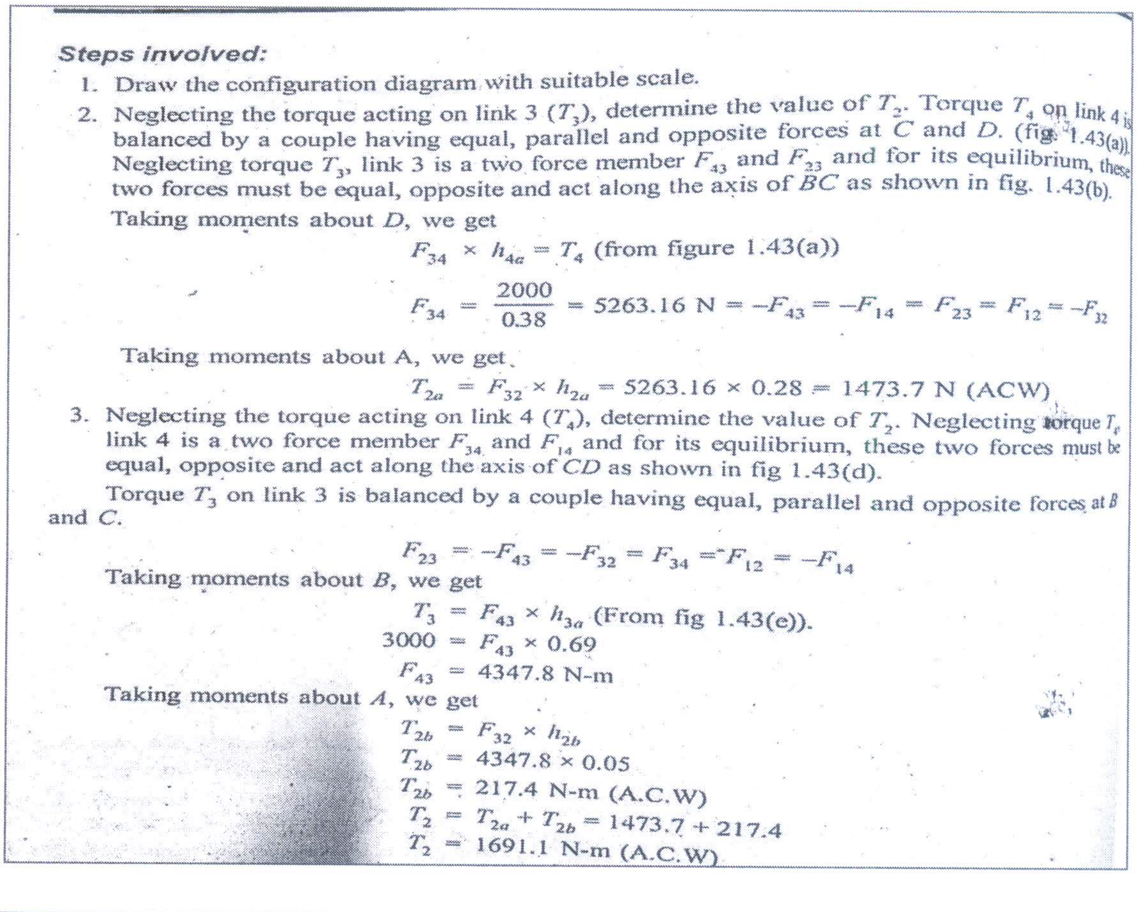
$$\therefore \text{ Total resisting torque} = T_2 = T_{2Q} + T_{2P} = 4320 + 7837.5 = 12157.5 \text{ N-m (C.W)}$$

4(b)



2M

2M



Steps involved:

1. Draw the configuration diagram with suitable scale.
2. Neglecting the torque acting on link 3 (T_3), determine the value of T_2. Torque T_4 on link 4 is balanced by a couple having equal, parallel and opposite forces at C and D. (fig. 1.43(a)). Neglecting torque T_3, link 3 is a two force member F_{43} and F_{23} and for its equilibrium, these two forces must be equal, opposite and act along the axis of BC as shown in fig. 1.43(b).

   Taking moments about D, we get

$$F_{34} \times h_{4a} = T_4 \text{ (from figure 1.43(a))}$$

$$F_{34} = \frac{2000}{0.38} = 5263.16 \text{ N} = -F_{43} = -F_{14} = F_{23} = F_{12} = -F_{32}$$

   Taking moments about A, we get.

$$T_{2a} = F_{32} \times h_{2a} = 5263.16 \times 0.28 = 1473.7 \text{ N (ACW)}$$

3. Neglecting the torque acting on link 4 (T_4), determine the value of T_2. Neglecting torque T_4, link 4 is a two force member F_{34} and F_{14} and for its equilibrium, these two forces must be equal, opposite and act along the axis of CD as shown in fig 1.43(d).

   Torque T_3 on link 3 is balanced by a couple having equal, parallel and opposite forces at B and C.

$$F_{23} = -F_{43} = -F_{32} = F_{34} = F_{12} = -F_{14}$$

   Taking moments about B, we get

$$T_3 = F_{43} \times h_{3a} \text{ (From fig 1.43(e)).}$$

$$3000 = F_{43} \times 0.69$$

$$F_{43} = 4347.8 \text{ N-m}$$

   Taking moments about A, we get

$$T_{2b} = F_{32} \times h_{2b}$$

$$T_{2b} = 4347.8 \times 0.05$$

$$T_{2b} = 217.4 \text{ N-m (A.C.W)}$$

$$T_2 = T_{2a} + T_{2b} = 1473.7 + 217.4$$

$$T_2 = 1691.1 \text{ N-m (A.C.W)}$$

1M

9448225772

4(c)	Damping is defined as the resistance to the motion of a vibrating body. Damping is broadly classified in to four types. 1. Viscous Damping 2. Dry friction or Coulomb Damping 3. Solid or Structural Damping 4. Slip or Interfacial Damping.	1M 4M

Signature of Course in charge **Signature of Module Coordinator** K. Rama **Signature of HOD/ME**

K. Rama

Signature of Chief Academic Coordinator **Signature of Principal**

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109

III SESSIONAL TEST QUESTION PAPER 2018 – 19 ODD SEMESTER

SET – B

USN ☐☐☐☐☐☐☐☐☐☐

Degree : B.E

Branch : Mechanical Engineering

Course Title : DYNAMICS OF MACHINERY

Duration : 90 Minutes

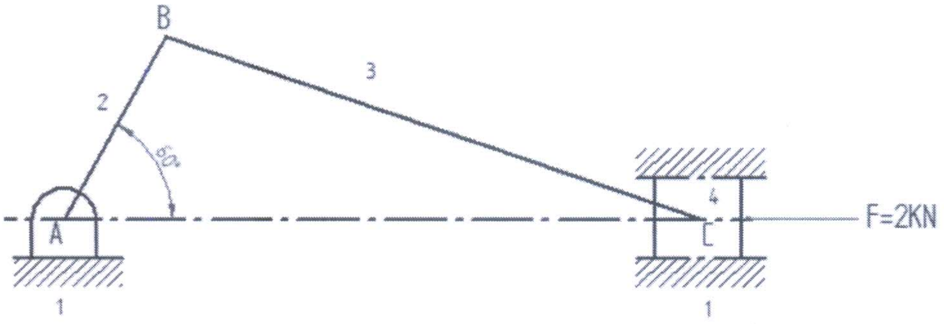
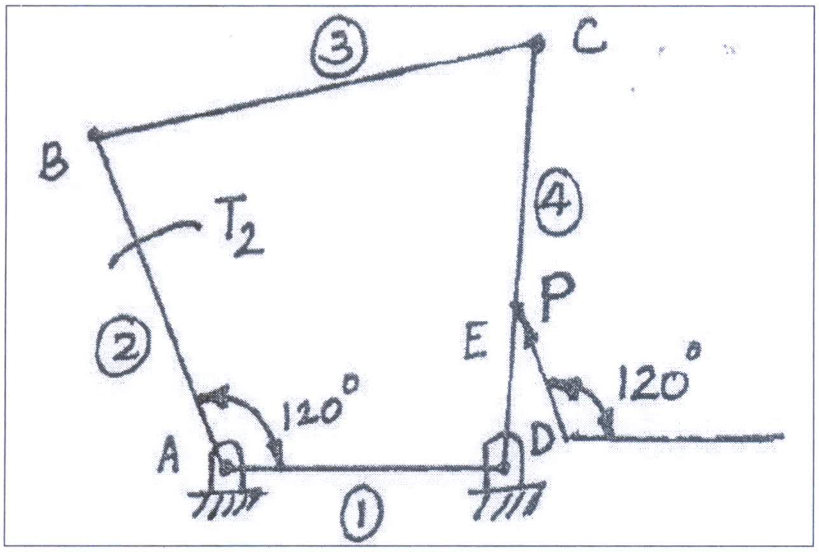
Semester : V A & B

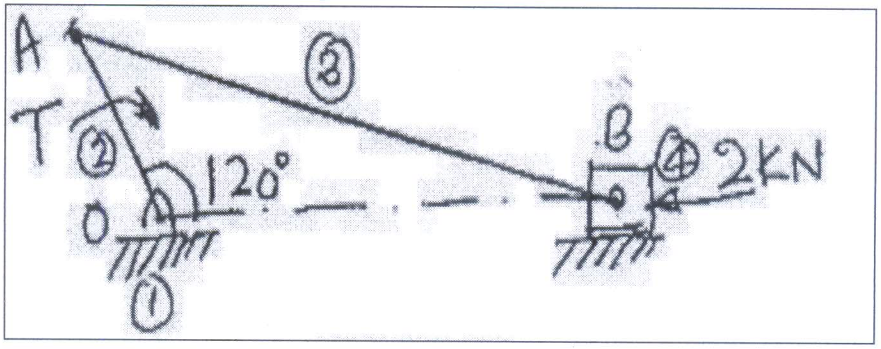
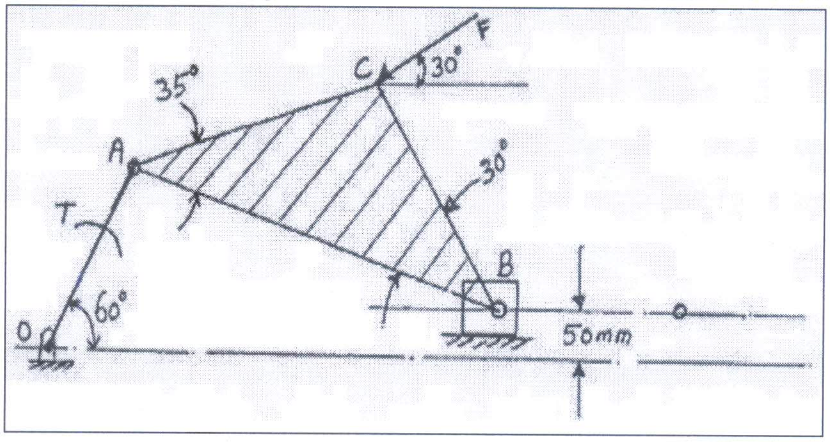
Course Code : 15ME52

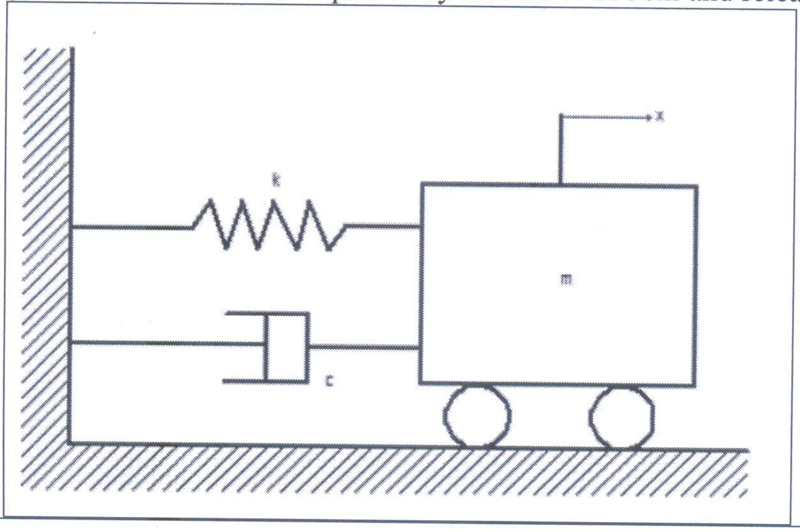
Date : 22-11-2018

Max Marks : 30

Note: Answer ONE full question from each part.

Q No.	Question	Marks	CO mapping	K-Level
	PART-A			
1(a)	**Determine** the required input torque on the crank of slider crank mechanism shown in figure, for static equilibrium. Take AB=80mm, BC=240mm. 	5	CO3	Applying (K3)
(b)	A four bar mechanism shown in figure is acted upon by a force of P= 100N 120^0 on link CD. The dimensions of the various links are AB=40mm, BC=60mm, CD=50mm, DA=30mm and DE=20mm. **Find** the magnitude and direction of input torque T_2 on link AB for the static equilibrium of the mechanism. 	5	CO3	Applying (K3)
(c)	**Establish** differential equation for spring mass damper system and derive	5	CO5	Analyzing

	equation for an under damped system.			(K4)
	OR			
2(a)	A slider crank mechanism is acted upon by a force of 2KN at B as shown in figure. OA=100mm, AB=450mm. **Determine** the input torque required on the crank OA for the static equilibrium of the mechanism.  	5	CO3	Applying (K3)
(b)	For the mechanism shown in figure **find** the required input torque for the static equilibrium. The lengths OA=250mm, AB=650mm and F=500N.  	5	CO3	Applying (K3)
(c)	Define logarithmic Decrement and **Establish** equation for the same.	5	CO5	Analyzi (K4)
	PART-B			
3(a)	With a neat sketch explain beats phenomenon and **Establish** equation for resultant motion.	5	CO4	Analyzing (K4)
(b)	**Divide** the given harmonic motion in to two harmonic motions, one having a phase angle of zero and the other of 45^0. Use both analytical and graphical method. $X - 10\sin(\omega t + \frac{\pi}{6})$	5	CO4	Analyzing (K4)
(c)	A vibrating system consists of mass of 25kg, a spring of stiffness 15kN/m and a damper. The damping provided is only 15% of the critical value. **Calculate** i) Critical Damping co-efficient ii) Damping factor iii) Natural frequency	5	CO5	Analyzing (K4)

	iv) Logarithmic Decrement v) Ratio of two consecutive amplitudes.			
	OR			
4(a)	**Establish** equation for work done by harmonic force.	5	CO4	Analyzing (K4)
(b)	**Determine** the algebraic sum of the harmonic motions given by X_1=2Cos(2t+0.5) and X_2=5Sin(2t+1)	5	CO4	Analyzing (K4)
	Find the equation of motion for the system shown in figure. When ξ=1.0, ξ=0.3, ξ=2.0, if the mass m is displaced by a distance of 3cm and released. 	5	CO5	Analyzing (K4)

17/11/18.

Signature of course incharge

Signature of Module Coordinator

K. Rama

signature of HOD/ME

K. Rama

Signature of Chief Academic Coordinator

Selected

20-11-18

Signature of Principal

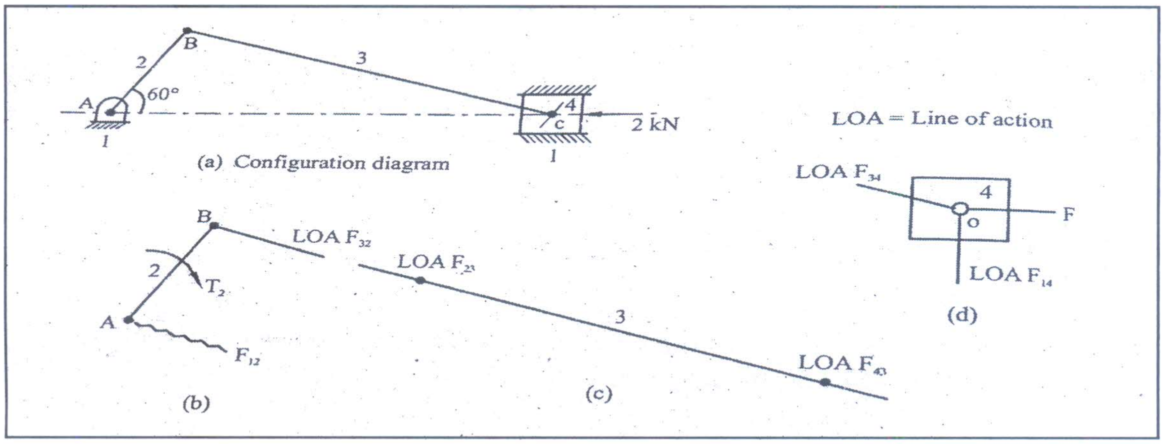
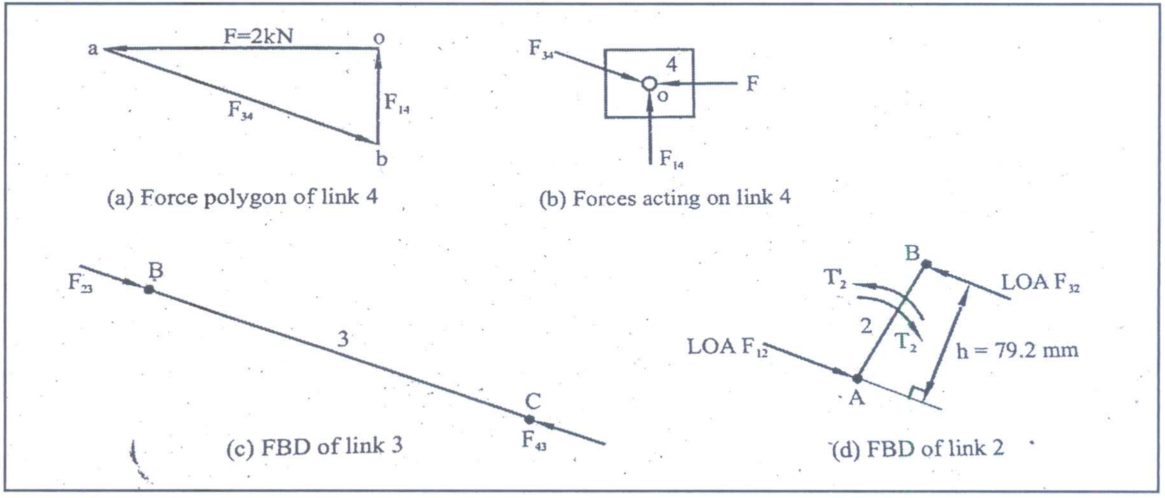
Set-B

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109

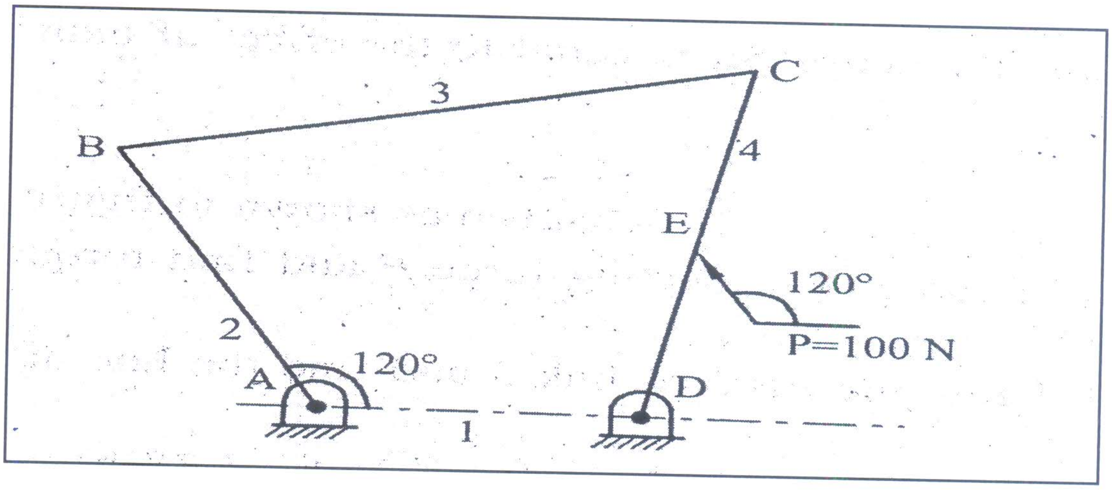
III SESSIONAL TEST QUESTION PAPER 2018 – 19 ODD SEMESTER

SCHEME AND SOLUTION

Degree : B.E
Branch : Mechanical Engineering
Course Title : DYNAMICS OF MACHINERY
Semester : V A & B
Course Code : 15ME52
Max Marks : 30

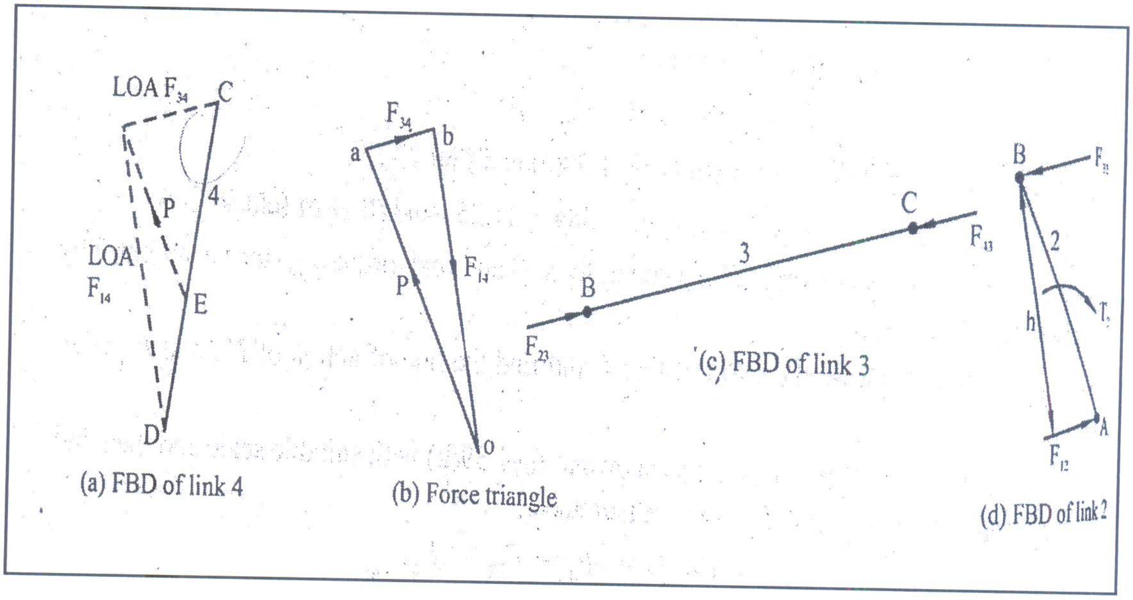
Q.NO.	POINTS	MARKS
1(a)	Drawing Space Diagram and Free Body Diagram.  	2M
	Analysis of Links:  	2M
	F_{34}= 2120N, F_{14}=600N, F_{23}=-F_{43}=2120N, F_{32}= F_{12}= 2120N Torque = T_2= F_{12} X h = 2120 X 0.0792 = 167.9 N-mm	1M

1(b) Space Diagram :



1M

Analysis of Links :



(a) FBD of link 4

(b) Force triangle

(c) FBD of link 3

(d) FBD of link 2

3M

F_{34}= 28N, F_{14}= 98N,

F_{34}= -F_{43}= F_{23} = -F_{32} =F_{12}

Torque T_2= F_{32} X h = 28 X 39 = 1092 N-mm

1M

1(c)

Consider a mathematical model of spring-mass-dashpot system which is supported elastically by a spring and a damper shown in below figure 5.5(a). Let k be the stiffness of the spring, m is the mass of the body and c be the damping co-efficient. Let the mass be displaced by a small amount x downwards. The external forces acting on the body are

a. The spring force kx acting in the upward direction.

b. The damping force $c\dot{x}$ acting in the upward direction.

Applying Newton's II Law

$$m\ddot{x} = \Sigma F_x$$

$$m\ddot{x} = -kx - c\dot{x}$$

$$m\ddot{x} + c\dot{x} + kx = 0 \qquad \text{-----(1)}$$

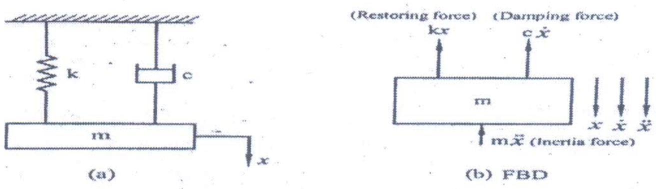


Fig.5.5 Damped-free vibration model

The equation (1) is a homogeneous linear differential equation of the second order and assuming a solution is of the form

$$x = e^{st}$$

$$\frac{dx}{dt} = \dot{x} = se^{st}$$

$$\frac{d^2x}{dt^2} = \ddot{x} = s^2e^{st}$$

Substituting these expressions in equation (1), we get

$$ms^2e^{st} + cse^{st} + ke^{st} = 0$$

$$(ms^2 + cs + k)e^{st} = 0$$

$$ms^2 + cs + k = 0 \qquad \text{-----(2)}$$

The above equation is called auxillary or charactersic equation of the system.

$$s^2 + \left(\frac{c}{m}\right)s + \left(\frac{k}{m}\right) = 0$$

2M

This equation is quadratic in s and its two roots are given by

$$s_{1,2} = \frac{-c}{2m} \pm \sqrt{\left(\frac{c}{2m}\right)^2 - \frac{k}{m}} \qquad \text{-----(3)}$$

These two roots give two solutions to equation (1)

$$x_1 = c_1e^{s_1t}\ ;\ x_2 = c_2e^{s_2t}$$

Thus the general solution of equation is given by combination of two solutions x_1 & x_2

$$x = c_1e^{s_1t} + c_2e^{s_2t}$$

$$x = c_1e^{\left\{\frac{-c}{2m}+\sqrt{\left(\frac{c}{2m}\right)^2-\frac{k}{m}}\right\}t} + c_2e^{\left\{\frac{-c}{2m}-\sqrt{\left(\frac{c}{2m}\right)^2-\frac{k}{m}}\right\}t} \qquad \text{-----(4)}$$

Where c_1 and c_2 are arbitary constants and can be determined from the initial conditions.

Critical damping co-efficient and damping ratio :

The quantity under a radical may either be zero, positive or negative. In the limiting case, the quantity under the radical is zero. The damping present in this case is called critical damping. The critical damping co-efficient c_c is defined as the value of the damping co-efficient c for which the radical sign in the equation (3) becomes zero. Also The critical damping co-efficient is the amount of damping required for a system to be critically damped.

1M

$$\left(\frac{c_c}{2m}\right)^2 - \frac{k}{m} = 0$$

$$\frac{c_c}{2m} = \sqrt{\frac{k}{m}} = \omega_n$$

$$c_c = 2\sqrt{km} = 2m\omega_n$$

For any damped system, the damping ratio ξ is defined as the ratio of the damping co-efficient to the critical damping co-efficient.

$$\xi = \frac{c}{c_c}$$

$$\frac{c}{2m} = \frac{c}{c_c} \cdot \frac{c_c}{2m} = \xi\omega_n$$

and hence,

$$s_{1,2} = (-\xi \pm \sqrt{\xi^2 - 1})\omega_n$$

Thus, the equation (4) can be written as

$$x = c_1 \cdot e^{\left(-\xi+\sqrt{\xi^2-1}\right)\omega_n t} + c_2 \cdot e^{\left(-\xi-\sqrt{\xi^2-1}\right)\omega_n t}$$

Hence general solution may be written as

$$x = c_1\, e^{\left(-\xi+i\sqrt{1-\xi^2}\right)\omega_n t} + c_2 e^{\left(-\xi-i\sqrt{1-\xi^2}\right)\omega_n t}$$

$$x = e^{-\xi\omega_n t}\{c_1 e^{i\sqrt{1-\xi^2}.\omega_n t} + c_2 e^{-i\sqrt{1-\xi^2}.\omega_n t}\}$$

$$x = e^{-\xi\omega_n t}\{(c_1 + c_2)\cos\sqrt{1-\xi^2}\,.\omega_n t + i\,(c_1 - c_2)\sin\sqrt{1-\xi^2}\,.\omega_n t\}$$

$$x = e^{-\xi\omega_n t}\{c_1'\cos\sqrt{1-\xi^2}\,.\omega_n t + c_2'\sin\sqrt{1-\xi^2}\,.\omega_n t\}$$

2M

$$\text{where } (c_1 + c_2) = c_1'$$

$$i(c_1 - c_2) = c_2'$$

$$x = X\sin(\omega_d t + \phi)\, e^{-\xi\omega_n t}$$

$$\text{where } c_1' = X\sin\phi\,;\ c_2' = X\cos\phi\,;\ \omega_d = \sqrt{1-\xi^2}\,\omega_n$$

$$X = \sqrt{(c'_1)^2 + (c'_2)^2}$$

$$\phi = \tan^{-1}(c_1'/c_2')$$

For underdamped free vibrations, the system oscillates about an equilibrium position. However each time it reaches equilibrium. the system's total energy level is less than at the previous time. The component $Xe^{-\xi\omega_n t}$ denotes, the amplitude of vibration decreases exponentially with time. A graphical reprasentation of the response of an under damped system with initial dispacement X starting with intial velocity v_0 as shown in above figure 5.6. It may be ubserved from the figure that the motion is oscillatory but not periodic. The amplitude of vibration is not constant during the motion but decreses for successive cycles and the oscilations occur at equal intervals of time. This time interval is designated as damped period of vibration and is given by

$$T_d = \frac{2\pi}{\omega_d}$$

Where the quantity ω_d is called damped natural frequency (which is always less than ω_n and is given by

$$\omega_d = \omega_n\sqrt{1-\xi^2}$$

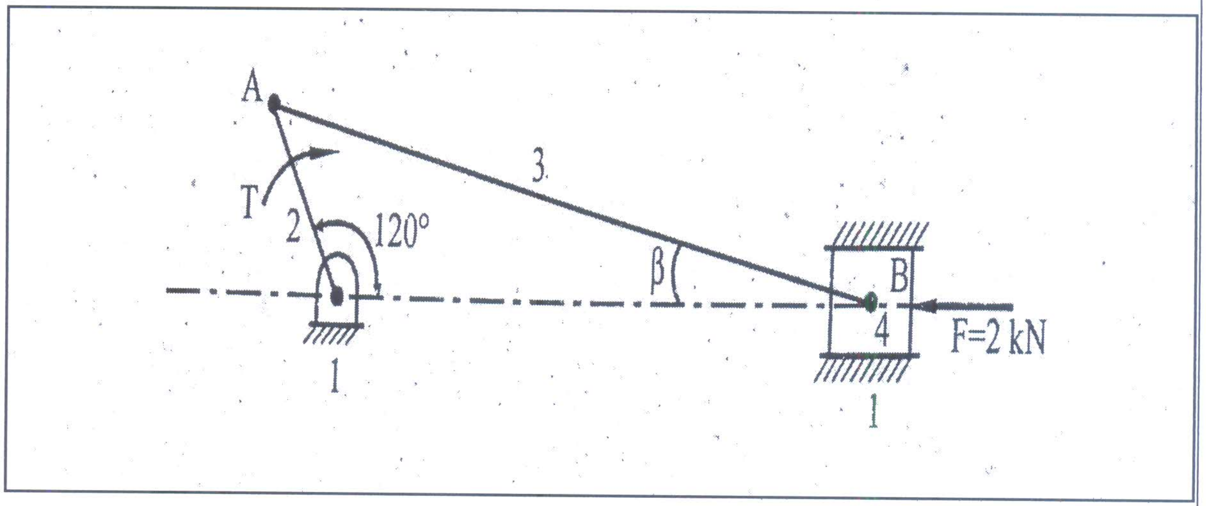
Also decrease in the frequency of damped vibration with increasing amount of damping.

Example : Shock absorber.

OR

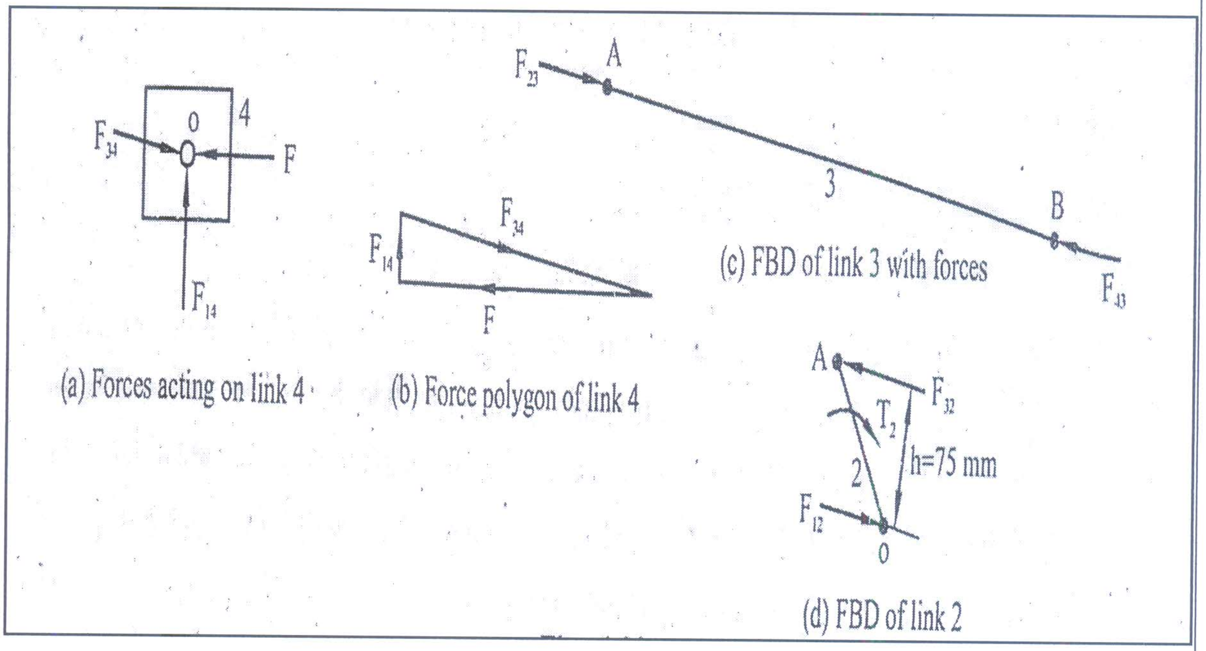
2(a)

Space Diagram :



1M

Analysis of Links:



(a) Forces acting on link 4

(b) Force polygon of link 4

(c) FBD of link 3 with forces

(d) FBD of link 2

3M

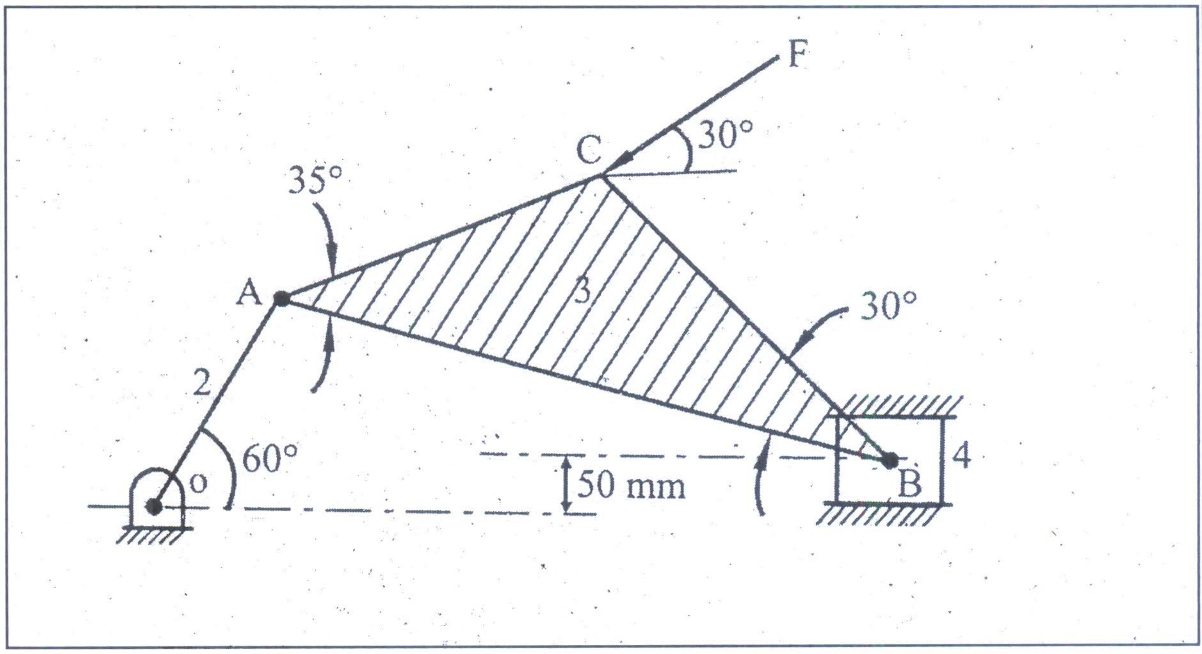
F_{34}= 2040N, F_{14}=580N, F_{23}=-F_{43}=2040N, F_{32}= F_{12}= 2040N

Torque = T_2= F_{12} X h = 2040 X 75 = 153000 N-mm

1M

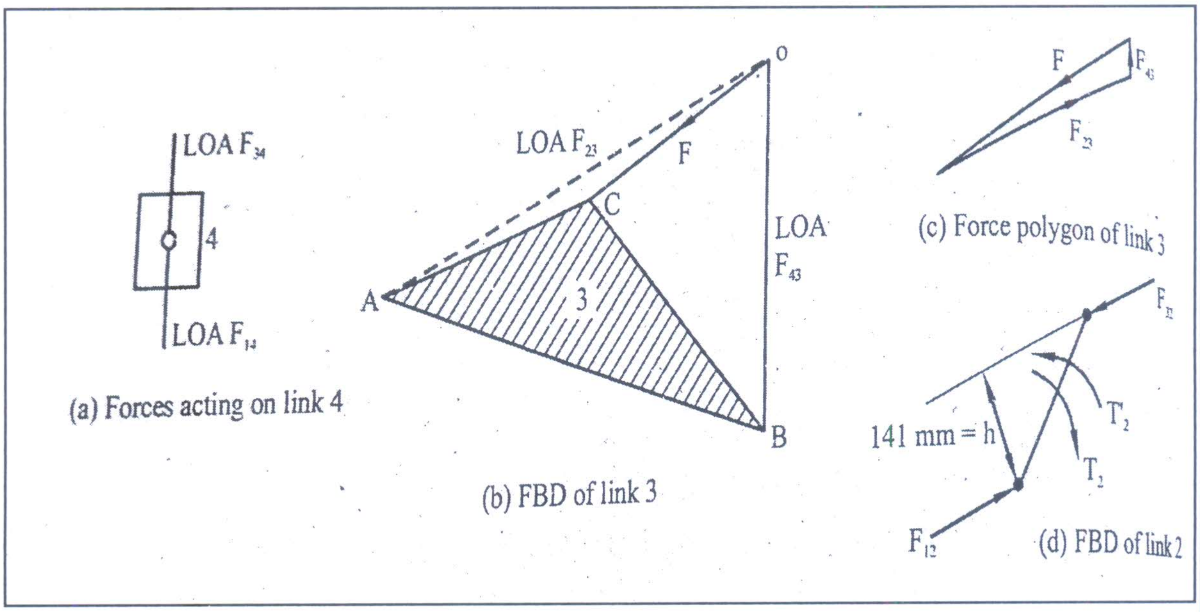
2(b)

Space Diagram:



1M

Analysis of Links:



(a) Forces acting on link 4

(b) FBD of link 3

(c) Force polygon of link 3

(d) FBD of link 2

3M

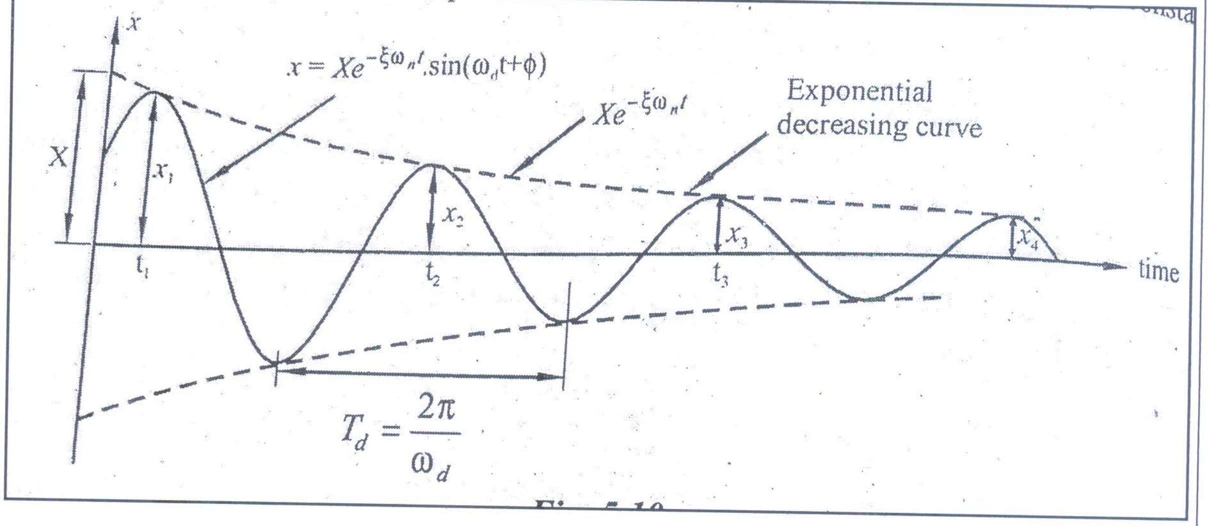
1M

F_{23}= 480N= - F_{32}, F_{43}= 60N

Torque = T_2= F_{32} X h = 480 X 141 = 67680 N-mm

2(c)

Logarithmic decrement is defined as the natural logarithm of any two successive amplitudes measured on same side of the mean position of an under damped system. 1M



By definition, $\delta = \ln \frac{x_1}{x_2}$

The displacemnt in an underdamped system is given by

$$x = Xe^{-\xi\omega_n t} \sin(\omega_d t + \phi)$$

This equation is an equation of harmonic motion in which $Xe^{-\xi\omega_n t}$ is the maximum mplitude. Maximum amplitude in a cycle will occur when $\sin(\omega_d t + \phi)$ is equal to unity. 2M

Maximum amplitude $= Xe^{-\xi\omega_n t}$

Let $x_1 = Xe^{-\xi\omega_n t_1}$ = Maximum amplitude at time t_1

$x_2 = Xe^{-\xi\omega_n t_2}$ = Maximum amplitude at time t_2

Hence the ratio of two successive amplitudes

$$\frac{x_1}{x_2} = \frac{Xe^{-\xi\omega_n t_1}}{Xe^{-\xi\omega_n t_2}} = e^{-\xi\omega_n(t_1-t_2)} = e^{\xi\omega_n(t_2-t_1)} \quad \text{-----(1)}$$

Time difference between two consecutive amplitudes is given by

$$T_d = t_2 - t_1 = \frac{2\pi}{\omega_d}$$

Hence equation (1) becomes 2M

$$\frac{x_1}{x_2} = e^{\xi\omega_n \cdot \frac{2\pi}{\omega_d}} = e^{\xi\omega_n \cdot \frac{2\pi}{\omega_n\sqrt{1-\xi^2}}}$$

$$\frac{x_1}{x_2} = e^{2\pi\xi/\sqrt{1-\xi^2}} \text{ and so on}$$

$$\frac{x_1}{x_2} = \frac{x_2}{x_3} = \frac{x_3}{x_4} = \text{--------} = e^{\frac{2\pi\xi}{\sqrt{1-\xi^2}}} \text{ (= constant)}$$

Taking natural logarithm of above equation, we get

$$ln \frac{x_1}{x_2} = \frac{2\pi\xi}{\sqrt{1-\xi^2}} \quad \text{OR}$$

$$\delta = \frac{2\pi\xi}{\sqrt{1-\xi^2}}$$

can be written as

PART-B

3(a)

When the two simple harmonic motions of slightly different frequencies or very close to each other are added, then resulting motion exhibits beat phenomenon. For example, let us consider a particle is subjected to two different harmonic motions given by

$$x_1 = A \sin \omega_1 t \;;\quad x_2 = B \sin \omega_2 t \text{ and } \Delta\omega = (\omega_2 - \omega_1)$$

The resultant motion is given by 1M

$$x = x_1 + x_2 = A \sin \omega_1 t + B \sin \omega_2 t$$

$$x = A \sin \omega_1 t + B \sin (\omega_1 + \Delta\omega)\, t$$

$$x = A \sin \omega_1 t + B\,[\sin \omega_1 t \,.\, \cos \Delta\omega t + \cos \omega_1 t \,.\, \sin \Delta\omega t]$$

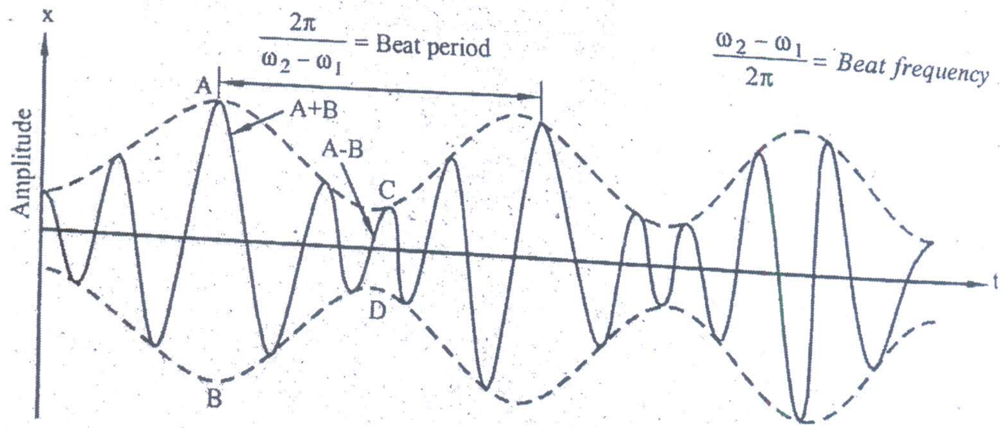
$$x = (A + B \cos \Delta\omega t) \sin \omega_1 t + (B \sin \Delta\omega t) \cos \omega_1 t$$

The resultant amplitude of resultant motion is given by

$$X = \sqrt{(A + B\cos\Delta\omega t)^2 + (B\sin\Delta\omega t)^2}$$

$$X = \sqrt{A^2 + B^2 + 2AB\cos\Delta\omega t}$$

When two motions are in phase with each other, $\Delta\omega = 0$ and the resultant amplitude is A + B where as when the two motion are in out of phase, $\Delta\omega = 180°$ and the resultant amplitude is A – B. Thus, the resultant amplitude keeps on changing from maximum value of (A + B) to minimum value of (A – B) with frequency $\Delta\omega$. 2M



2M

Fig. 4.7

If two harmonic motions have different frequencies, then the resultant motion is non–harmonic. When the two frequencies are only slightly different from each other, the phase difference between the rotating vectors keeps on shifting slowly and continuously. At a time when they are in phase with each other, the amplitude of resultant vibration is maximum $(A + B)$ and when they are out of phase, the amplitude of resultant vibration is minimum $(A – B)$. Thus, the amplitude of resultant vibration continuously keeps on changing from maximum $(A + B)$ to minimum $(A – B)$. This phenomena is known as beats. In machines and structures, the beat phenomenon occurs when the forcing frequency is close to the natural frequency of the system.

3(b)

Analytical Method

Given $x = 10 \sin(\omega t + 30°)$

Let the equations are :

$$x_1 = A \sin \omega t$$
$$x_2 = B \sin(\omega t + 45°)$$

The resultant motion is given by

$$x = x_1 + x_2 = A \sin \omega t + B \sin(\omega t + 45°)$$

Since the frequencies are same for both the harmonic motions,

$$10 \sin(\omega t + 30°) = A \sin \omega t + B \sin(\omega t + 45°)$$

$$10 \sin \omega t . \cos 30° + 10 \cos \omega t . \sin 30° = A \sin \omega t + B \sin \omega t . \cos 45° + B \cos \omega t . \sin 45°$$ 2.5M

$$\sin \omega t (10 \cos 30°) + \cos \omega t (10 \sin 30°) = (A + B \cos 45°) \sin \omega t + (B \sin 45°) \cos \omega t$$

Equating the co-efficients of $\sin \omega t$ and $\cos \omega t$

$$10 \cos 30° = (A + B \cos 45)$$
$$10 \sin 30° = B \sin 45°$$
$$\therefore B = 7.07$$
$$A = 3.67$$

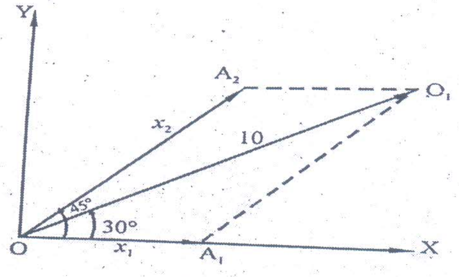
Hence the equations of harmonic motions can be written as

$$x_1 = 3.67 \sin(\omega t + 0)$$
$$x_2 = 7.07 \sin(\omega t + 45°)$$

Procedure for Graphical Method

a) First draw OX and OY lines.
b) Draw vector $OO_1 = 10$ units choosing proper scale at an angle 30° with OX line.
c) As one of the components have phase angle of 0°, so draw a line along OX line.
d) Draw another line making angle 45° with OX line.
e) From point O_1, draw a line parallel to 0° line. This line intersect 45° line at A_2. 2.5M
f) Draw another line parallel to 45° line. This line intersect 0° line at A_1. Measure OA_1 and OA_2. On measurement, $OA_1 = 3.6$ units and $OA_2 = 7$ units. Hence,

$$x_1 = 3.6 \sin(\omega t + 0)$$
$$x_2 = 7 \sin(\omega t + 45°)$$



3(c)

Given $m = 25\ kg$, $k = 15 \times 10^3\ N/m$

Damping provided = 15% of critical value of damping

ie., $c = 15\%\ c_c$

$c = 0.15\ c_c$

$$\frac{c}{c_c} = 0.15$$

$$\omega_n = \sqrt{\frac{k}{m}} = \sqrt{\frac{15\times10^3}{25}}$$

$\omega_n = 24.49\ rad/sec$

1M

(i) Critical damping co-efficient (c_c)

$$c_c = 2m\omega_n = 2 \times 25 \times 24.49$$

$$c_o = 1224.7\ N\text{-}sec/m$$

(ii) Damping factor (ξ)

$$\xi = \frac{c}{c_c}$$

$$\xi = \frac{0.15c_c}{c_c}$$

$$\xi = 0.15$$

1M

(iii) Natural frequency of damped vibrations (ω_d)

$$\omega_d = \omega_n\sqrt{1-\xi^2}$$

$$\omega_d = 24.49\sqrt{1-0.15^2}$$

$$\omega_d = 24.22\ rad/sec$$

(iv) Logarithmic decrement (δ)

$$\delta = \frac{2\pi\xi}{\sqrt{1-\xi^2}} = \frac{2\pi\times0.15}{\sqrt{1-\xi^2}}$$

$$\delta = 0.9533$$

2M

(v) Ratio of two consecutive amplitudes $\left(\frac{x_0}{x_1}\right)$

$$\delta = \ln\frac{x_0}{x_1}$$

$$\frac{x_0}{x_1} = e^{\delta}$$

1M

$$\frac{x_0}{x_1} = e^{0.9533}$$

$$\frac{x_0}{x_1} = 2.594$$

OR

4(a)

The concept of workdone by a harmonic force on a harmonic motion is very important because it helps to understand the phenomena of resonance more clearly. Let us assume that a harmonic force $F = F_0 \sin \omega t$ is acting on a vibrating body having S.H.M $x = X_0 \sin(\omega t - \phi)$. The workdone by the force F during an interval when the body moves through a small displacement dx is given by 1M

$$dw = F.dx = F.\left(\frac{dx}{dt}\right).dt$$

The workdone in one cycle is given by (for a period 0 to T seconds)

$$W = \int_0^T F\left(\frac{dx}{dt}\right)dt = \int_0^T [F_0 \sin \omega t]\frac{d}{dx}[X_0 \sin(\omega t - \phi)].dt$$

$$W = \int_0^T F_0 \sin \omega t.[X_0 \omega \cos(\omega t - \phi)].dt = F_0 X_0 \omega \int_0^T \sin \omega t.\cos(\omega t - \phi).dt$$ 2M

$$W = F_0 X_0 \omega \int_0^T \sin \omega t.[\cos \omega t.\cos \phi + \sin \omega t.\sin \phi].dt$$

$$W = F_0 X_0 \omega \left[\cos\phi \int_0^T \sin \omega t.\cos \omega t.dt + \sin\phi \int_0^T \sin^2 \omega t.dt\right]$$

$$W = F_0 X_0 \omega \left[\cos\phi \int_0^{2\pi/\omega} \frac{\sin 2\omega t}{2}.dt + \sin\phi \int_0^{2\pi/\omega} \left(\frac{1 - \cos 2\omega t}{2}\right).dt\right]$$

$$W = F_0 X_0 \omega \,[0 + \frac{\pi}{\omega}.\sin\phi]$$ 2M

$$W = \pi F_0 X_0 \sin \phi$$

1. When the phase angle $\phi = 0$ or any integer multiple of π, the work done per cycle is zore. This means that the force is in phase with the displacement and no work is done per cycle.
2. When the phase angle $\phi = 90°$ (i.e, the force is ahead of displacement by 90° or in phase with velocity), the workdone by the force is maximum and is equal to $\pi F_0 X_0$

4(b)

The resultant motion is given by

$$x = x_1 + x_2 = 2 \cos(\omega t + 0.5) + 5 \sin(\omega t + 1.0)$$

Since the frequency is same for both harmonic motions, the resultant motion can also b written as

$$x = A \sin(\omega t + \phi)$$

$$A \sin(\omega t + \phi) = 2 \cos(\omega t + 0.5) + 5 \sin(\omega t + 1.0)$$

$$A \sin \omega t . \cos \phi + A \cos \omega t . \sin \phi = 2 \cos \omega t . \cos 0.5 - 2 \sin \omega t . \sin 0.5 + 5 \sin \omega t . \cos 1.0 + 5 \cos \omega t . \sin 1.0$$

$$\sin \omega t (A \cos \phi) + \cos \omega t (A \sin \phi) = (5 \cos 1.0 - 2 \sin 0.5) \sin \omega t + (2 \cos 0.5 + 5 \sin 1.0) \cos \omega t$$

$$\cos \omega t (A \sin \phi) + \sin \omega t (A \cos \phi) = 1.74 \sin \omega t + 5.90 \cos \omega t$$

Equating the co-efficient of $\sin \omega t$ and $\cos \omega t$

$$A \sin \phi = 5.90$$

$$A \cos \phi = 1.74$$

$$A^2 = 37.83$$

$$A = 6.15$$

$$\tan \phi = 3.39$$

$$\phi = 73.56^\circ$$

Resultant motion is given by

$$x = 6.15 \sin(\omega t + 73.6^\circ)$$

2.5M

Graphical Method

$$x_1 = 2 \cos(\omega t + 0.5)$$

$$= 2 \sin(\omega t + 118^\circ)$$

$$x_2 = 5 \sin(\omega t + 57.3^\circ)$$

Resultant motion is given by

$$x = 6.2 \sin(\omega t + 72^\circ)$$

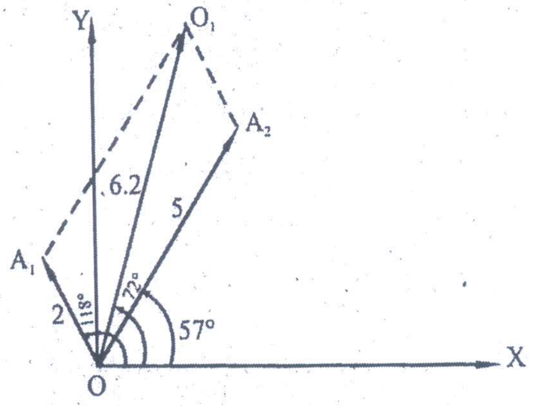


Fig. 4.11

2.5M

4(c)

Solution :

(a) When $\xi = 1.0$, the system is critically damped

$$x = (c_1 + c_2 t)\, e^{-\omega_n t}$$

Using initial conditions

$$x = 3\ cm \text{ at } t = 0$$
$$\dot{x} = 0 \text{ at } t = 0$$
$$3 = c_1$$
$$\dot{x} = e^{-\omega_n t} \,.\, c_2 + (c_1 + c_2 t)(-\omega_n)\, e^{-\omega_n t}$$
$$0 = c_2 - c_1 \omega_n$$
$$c_2 = 3\omega_n$$

2M

Hence the solution becomes

$$x = (3 + 3\omega_n t)\, e^{-\omega_n t}$$
$$x = 3(1 + \omega_n t)\, e^{-\omega_n t}$$

(b) When $\xi = 0.3$, the system is underdamped

$$x = X e^{-\omega_n t} \sin(\omega_d t + \phi)$$
$$x = X e^{-0.3\omega_n t} \sin(0.953\omega_n t + \phi)$$
$$\dot{x} = X[\, e^{-0.3\omega_n t}(0.953\omega_n) \cos(0.953\omega_n t + \phi) + \sin(0.953\ \omega_n t + \phi)(-0.3\ \omega_n)\, e^{-0.3\omega_n t}\,]$$
$$\dot{x} = X e^{-0.3\omega_n t}[\cos(0.953\omega_n t + \phi)(0.953\ \omega_n) - (0.3\ \omega_n) \sin(0.953\ \omega_n t + \phi)]$$

$$\omega_d = \omega_n \sqrt{1-\xi^2}$$
$$= \omega_n \sqrt{1-0.3^2}$$
$$= 0.953\ \omega_n$$

Using initial conditions

$$x = 3 \text{ at } t = 0$$
$$\dot{x} = 0 \text{ at } t = 0$$
$$3 = X \sin\phi \qquad \text{-----(1)}$$
$$0 = X[0.953\ \omega_n \,.\, \cos\phi - (0.3\ \omega_n) \sin\phi\,]$$
$$X\, 0.3\ \omega_n \sin\phi = X\, 0.953\ \omega_n \cos\phi$$
$$\tan\phi = \frac{0.953}{0.3}$$
$$\phi = 72^\circ$$
$$X = {}^{3}\!/_{\sin\phi} = 3.15$$

2M

The equation of motion is given by

$$x = 3.15\ e^{-0.3\omega_n t} \sin(0.953\ \omega_n t + 72^\circ)$$

1M

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Signature of Course in charge

Signature of Module Coordinator

K. Rana

Signature of HOD/ME

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Signature of Chief Academic Coordinator

17/11/18

Signature of Principal

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DEPARTMENT OF MECHANICAL ENGINEERING
ASSIGNMENT QUESTIONS

Academic Year	**2018-2019**		
Batch	**2016-2020**		
Year/Semester/section	**III/V/B**		
Subject Code-Title	**15ME52-DYNAMICS OF MACHINES**		
Name of the Instructor	**Mr. ANILKUMAR A**	**Dept**	**ME**

Assignment No: 1 **Total marks:20**

Date of Issue: 01-09-2018 **Date of Submission: 10-09-2018**

Sl.No	Assignment Questions	K Level	CO	Marks
1.	**Explain** the following terms i) Sensitivity ii) Stability iii)Isochronous iv)Controlling force v) Hunting vi) Governor Effort & Power	UNDERSTANDING (K2)	CO1	2
2.	**Derive** an expression for i) Height of a porter governor. ii) Effort and power of porter governor	APPLYING (K3)	CO1	2
3.	In a spring-loaded governor of the Hartnell type, the mass of each ball is 5 kg and the lift of the sleeve is 50 mm. The speed at which the governor begins to float is 240 rpm, and at this speed the radius of the ball path is 110mm. The mean working speed of the governor is 20 times the range of speed when friction is neglected. If the lengths of ball and roller arm of the bell crank lever are 120 mm and 100 mm respectively and if the distance between the centre of pivot of bell crank lever and axis of governor spindle is 140 mm, determine the initial compression of the spring taking into account the obliquity of arms. If friction is equivalent to a force of 30 N at the sleeve, **Find** the total alteration in speed before the sleeve begins to move from mid-position.	APPLYING (K3)	CO1	2
4.	In an engine governor of the Porter type, the upper and lower arms are 200 mm and 250 mm respectively and pivoted on the axis of rotation. The mass of the central load is 15 kg, the mass of each ball is 2 kg and friction of the sleeve together with the resistance of the operating gear is equal to a load of 25 N at the sleeve. If the limiting inclinations of the upper arms to the vertical are 30° and 40°,**Determine** range of speed of the governor, taking friction into account.	APPLYING (K3)	CO1	2
5.	The upper arms of a Porter governor have lengths 350 mm and are pivoted on the axis of rotation. The lower arms have lengths 300 mm and are attached to the sleeve at a distance of 40mm from the axis.	APPLYING (K3)	CO1	2

<table>
<tr><td></td><td>Each ball has a mass of 4 kg and mass on the sleeve is 45 kg. Calculate the equilibrium speed for a radius of rotation of 200 mm and find also the effort and power of the governor for 1 per cent speed change.</td><td></td><td></td><td></td></tr>
<tr><td>6.</td><td>Apply the knowledge of balancing to explain static and dynamic balancing,</td><td>APPLY NG (K3)</td><td>CO2</td><td>2</td></tr>
<tr><td>7.</td><td>Four masses A, B, C and D as shown below are to be completely balanced.
<table>
<tr><th></th><th>A</th><th>B</th><th>C</th><th>D</th></tr>
<tr><td>Mass (kg)</td><td>—</td><td>30</td><td>50</td><td>40</td></tr>
<tr><td>Radius (mm)</td><td>180</td><td>240</td><td>120</td><td>150</td></tr>
</table>
The planes containing masses B and C are 300 mm apart. The angle between planes containing B and C is 90°. B and C make angles of 210° and 120° respectively with D in the same sense. Calculate :
1. The magnitude and the angular position of mass A ; and
2. The position of planes A and D.</td><td>APPLYING (K3)</td><td>CO2</td><td>2</td></tr>
<tr><td>8.</td><td>A shaft is supported in bearings 1.8 m apart and projects 0.45 m beyondbearings at each end. The shaft carries three pulleys one at each end and one at the middle of its length. The mass of end pulleys is 48 kg and 20 kg and their centre of gravity are 15 mm and 12.5mm respectively from the shaft axis. The centre pulley has a mass of 56 kg and its centre of gravity is 15 mm from the shaft axis. If the pulleys are arranged so as to give static balance, Calculate :
1. relative angular positions of the pulleys, and 2. dynamic forces produced on the bearings when
the shaft rotates at 300 r.p.m.</td><td>APPLYING (K3)</td><td>CO2</td><td>2</td></tr>
<tr><td>9.</td><td>Classify and Explain types of vibration</td><td>ANALYZING (K4)</td><td>CO4</td><td>2</td></tr>
<tr><td>10.</td><td>Classify and explain free vibration with neat skethes</td><td>ANALYZING (K4)</td><td>CO4</td><td>2</td></tr>
</table>

Signature of course in charge

Signature of Module Coordinator

signature of HOD/ME

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ACADEMIC CO-ORDINATOR
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Signature of Principal

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KSIT Bangalore

DEPARTMENT OF MECHANICAL ENGINEERING

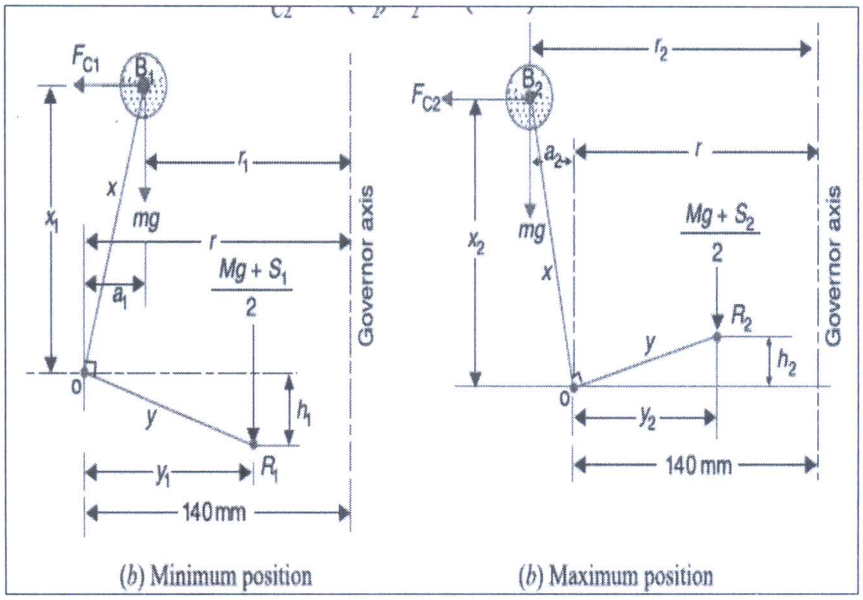
Scheme

Academic Year	**2018-2019**		
Batch	**2016-2020**		
Year/Semester/section	**III/V/B**		
Subject Code-Title	**15ME52-DYNAMICS OF MACHINES**		
Name of the Instructor	**Mr. ANILKUMAR A**	**Dept**	**ME**

Assignment No: 1 **Total marks:20**

Date of Issue: 01-09-2018 **Date of Submission: 10-09-2018**

Sl.No	Assignment Questions	K Level	CO	Marks
1.	i) **Sensitivity**: Sensitivity of a governor is defined as the ratio of difference between maximum speed & minimum speed to mean speed ii)**Stability:** A governor is said to be stable if there is one equilibrium speed for each radius of rotation and this speed increases with the radius iii)**Isochronous**: A governor is said to be isochronous if, neglecting friction, the equilibrium speed is the same for all radii of the balls iv)**Controlling force:** Controlling Force is the inward radial force exerted on each ball of a centrifugal governor by the arms, spring, etc. which are attached to it. v) **Hunting:** The continuous process of governor fluctuating above and below the mean speed is called as Hunting. vi) **Governor Effort & Power:** Governor Effort is the mean force exerted on the sleeve to raise it or lower it for a given percentage change in speed. **Power** is the work done on the sleeve for the given percentage change of speed. **Governor Power = Mean Effort X Lift of sleeve**	UNDERSTANDING (K2)	CO1	2
2.	**Height of a porter governor** $\boxed{N^2 = \frac{m+\frac{M}{2}(1+q)}{m} \times \frac{g}{h}\left(\frac{60}{2\pi}\right)^2 = \frac{m+\frac{M}{2}(1+q)}{m} \times \frac{895}{h}}$ **Effort**	APPLYING (K3)	CO1	2

	P = Mean force exerted on the sleeve during the increase in speed the effort of the governor. $P = \frac{(M_1 - M)\,g}{2} = \frac{(m+M)\,[(1+c)^2 - 1]\,g}{2}$ $= \frac{(m+M)\,[1+c^2+2c-1]\,g}{2} = c\,(m+M)\,g$ . . . Governor power $= c\,(m+M)\,g \times 2\,h\left(\frac{2c}{1+2c}\right) = \frac{4c^2}{1+2c}(m+M)\,g.h$			
3.	 (*b*) Minimum position (*b*) Maximum position $h = (r_2 - r_1)\frac{y}{x}$ $r_2 = r_1 + h \times \frac{x}{y} = 0.11 + 0.05 \times \frac{0.12}{0.1} = 0.17$ m **centrifugal force at the minimum speed,** $F_{C1} = m\,(\omega_1)^2\,r_1 = 5\,(25.14)^2\,0.11 = 347.6$ N centrifugal force at the maximum speed, $F_{C2} = m\,(\omega_2)^2\,r_2 = 5\,(26.43)^2\,0.17 = 593.8$ N $a_2 = r_2 - r = 0.17 - 0.14 = 0.03$ m $x_2 = x_1 = 0.1162$ m . . .(∵ $a_2 = a_1$) $y_2 = y_1 = 0.0986$ m . . .(∵ $h_2 = h_1$) $\frac{M.g + S_1}{2} \times y_1 = F_{C1} \times x_1 - m.g \times a_1$ $\frac{S_1}{2} \times 0.0968 = 347.6 \times 0.1162 - 5 \times 9.81 \times 0.03 = 38.9$ N $S_1 = 2 \times 38.9/0.0968 = 804$ N	APPLYING (K3)	CO1	2

$$\frac{M.g + S_2}{2} \times y_2 = F_{C2} \times x_2 + m.g \times a_2$$

$$\frac{S_2}{2} \times 0.0968 = 593.8 \times 0.1162 + 5 \times 9.81 \times 0.03 = 70.47 \text{ N}$$

$$S_2 = 2 \times 70.47/0.0968 = 1456 \text{ N}$$

stiffness of the spring

$$s = \frac{S_2 - S_1}{h} = \frac{1456 - 804}{50} = 13.04 \text{ N/mm}$$

Initial compression of the spring

$$= \frac{S_1}{s} = \frac{804}{13.04} = 61.66 \text{ mm} \quad \text{Ans.}$$

Total alternation in speed when friction is taken into account

We know that spring force for the mid-position,

$$S = S_1 + h_1.s = 8.4 + 25 \times 13.04 = 1130 \text{ N} \quad \ldots(\because h_1 = h/2 = 25 \text{ mm})$$

and mean angular speed, $\omega = \frac{\omega_1 + \omega_2}{2} = \frac{25.14 + 26.43}{2} = 25.785$ rad/s

or $N = \omega \times 60 / 2\pi = 25.785 \times 60 / 2\pi = 246.2$ r.p.m.

∴ Speed when the sleeve begins to move downwards from the mid-position,

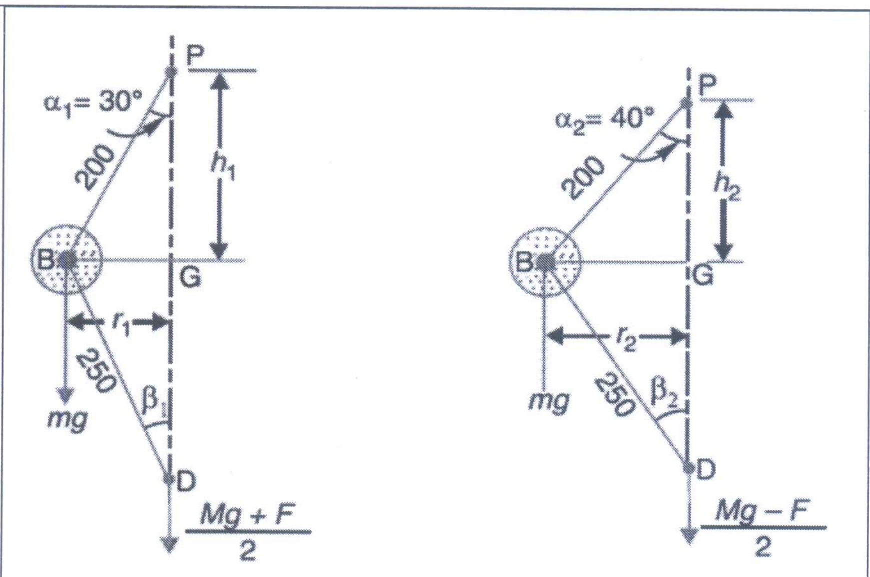
$$N' = N\sqrt{\frac{S-F}{S}} = 246.2\sqrt{\frac{1130-30}{1130}} = 243 \text{ r.p.m.}$$

and speed when the sleeve begins to move upwards from the mid-position,

$$N'' = N\sqrt{\frac{S+F}{S}} = 246.2\sqrt{\frac{1130+30}{1130}} = 249 \text{ r.p.m.}$$

∴ Alteration in speed $= N'' - N' = 249 - 243 = 6$ r.p.m. Ans.

4.



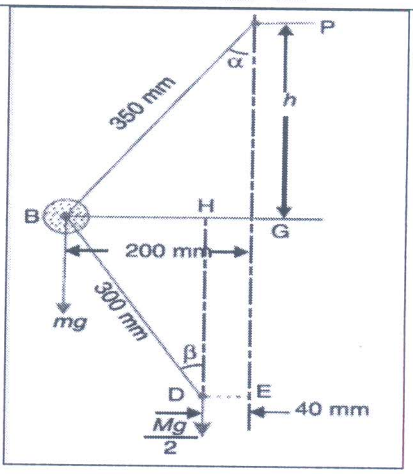
All dimensions in mm.

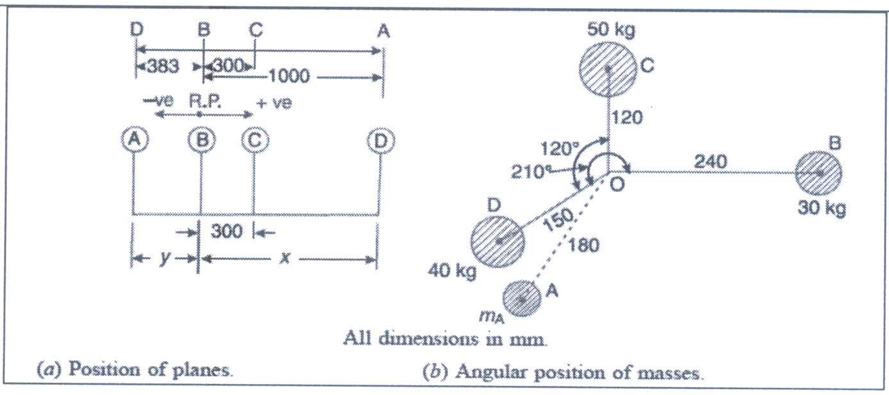
(*a*) Minimum position. (*b*) Maximum position.

APPLYING (K3)

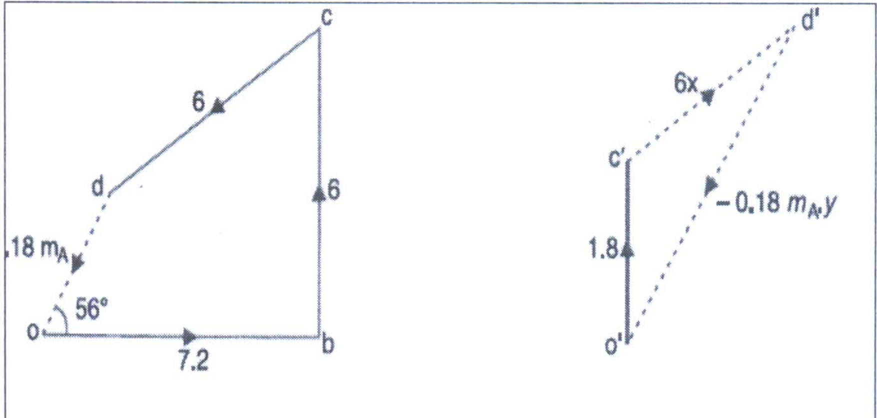
CO1

2

	$r_1 = BG = BP \sin 30^\circ = 0.2 \times 0.5 = 0.1$ m $h_1 = PG = BP \cos 30^\circ = 0.2 \times 0.866 = 0.1732$ m $\tan \beta_1 = BG/DG = 0.1/0.23 = 0.4348$ $\tan \alpha_1 = \tan 30^\circ = 0.5774$ $q_1 = \frac{\tan \beta_1}{\tan \alpha_1} = \frac{0.4348}{0.5774} = 0.753$ $(N_1)^2 = \frac{m.g + \left(\frac{M.g - F}{2}\right)(1 + q_1)}{m.g} \times \frac{895}{h_1}$ $= \frac{2 \times 9.81 + \left(\frac{15 \times 9.81 - 24}{2}\right)(1 + 0.753)}{2 \times 9.81} \times \frac{895}{0.1732} = 33596$ $N_1 = 183.3$ r.p.m. $r_2 = BG = BP \sin 40^\circ = 0.2 \times 0.643 = 0.1268$ m $h_2 = PG = BP \cos 40^\circ = 0.2 \times 0.766 = 0.1532$ m $(N_2)^2 = \frac{m.g + \left(\frac{m.g + F}{2}\right)(1 + q_2)}{m.g} \times \frac{895}{h_2}$ $= \frac{2 \times 9.81 + \left(\frac{15 \times 9.81 + 24}{2}\right)(1 + 0.703)}{2 \times 9.81} \times \frac{895}{0.1532} = 49\ 236$ $N_2 = 222$ r.p.m. range of speed $= N_2 - N_1 = 222 - 183.3 = 38.7$ r.p.m. Ans.			
5.	 $h = PG = \sqrt{(PB)^2 - (BG)^2}$ $= \sqrt{(0.35)^2 - (0.2)^2} = 0.287$ m $\tan \alpha = \frac{BG}{PG} = \frac{0.2}{0.287} = 0.697$	APPLYING (K3)	CO1	2

	$\tan\beta = BH/DH = 0.16/0.254 = 0.63$ $q = \frac{\tan\beta}{\tan\alpha} = \frac{0.63}{0.697} = 0.904$ $N^2 = \frac{m + \frac{M}{2}(1+q)}{m} \times \frac{895}{h} = \frac{4 + \frac{45}{2}(1+0.904)}{4} \times \frac{895}{0.287} = 3$ $N = 191$ r.p.m. Ans. effort of the governor, $P = c\left(\frac{2m}{1+q} + M\right)g = 0.01\left(\frac{2\times 4}{1+0.904} + 45\right)9.81 = 4.8$ N Ans. power of the governor $= \frac{4c^2}{1+2c}\left[m + \frac{M}{2}(1+q)\right]g.h$ $= \frac{4\,(0.01)^2}{1+2\times 0.01}\left[4 + \frac{45}{2}(1+0.904)\right]9.81\times 0.287 = 0.052$ N-m $= 52$ N-mm Ans.			
6.	If the centre of gravity of all rotating masses is made to coincide with the axis of rotation, a state is achieved when bearings will carry no additional reaction. However, the masses may still cause some net bending moment on the shaft. Such bending moment will keep changing its plane and thus cause shaft to vibrate. Connecting the masses in such a way that bending moment is made to vanish will result in situation when shaft will not vibrate. The balancing when only centers of gravity of attached mass system lies on axis of rotation is known as static balancing. The balancing with centers of attached mass system made to coincide with axis of rotation and no net bending moment acting on shaft is called dynamic balancing. In dynamic balancing forces and moments both are to be balanced.	**APPLYING (K3)**	**CO2**	2
7.	 (*a*) Position of planes. (*b*) Angular position of masses.	**APPLYING (K3)**	**CO2**	2

Plane (1)	Mass (m) kg (2)	Radius (r) m (3)	Cent.force ÷ ω^2 (m.r) kg-m (4)	Distance from plane B (l) m (5)	Couple ÷ ω^2 (m.r.l) kg-m^2 (6)
A	m_A	0.18	0.08 m_A	$-y$	$-0.18\ m_A.y$
B (R.P)	30	0.24	7.2	0	0
C	50	0.12	6	0.3	1.8
D	40	0.15	6	x	6x



(c) Force polygon.

(d) Couple polygon.

$$6\,x = \text{vector } c'\,d' = 2.3 \text{ kg-m}^2 \text{ or } x = 0.383 \text{ m}$$

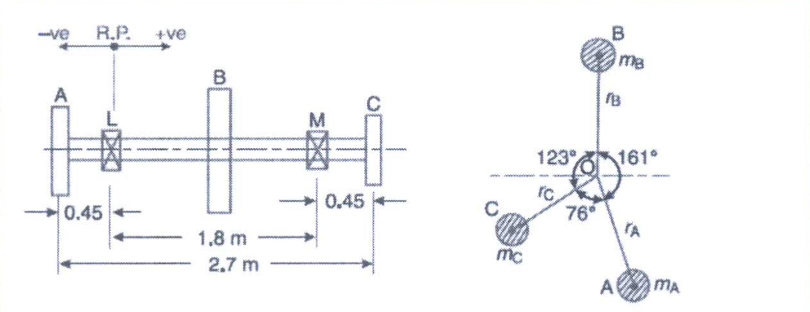
$$-0.18\ m_A.y = \text{vector } o'\,d' = 3.6 \text{ kg-m}^2$$

$$-0.18 \times 20\,y = 3.6 \quad \text{or} \quad y = -1 \text{ m}$$

The negative sign indicates that the plane *A* is not towards left of *B* as assumed but it is 1 m or 1000 mm towards right of plane *B*. Ans.

8.

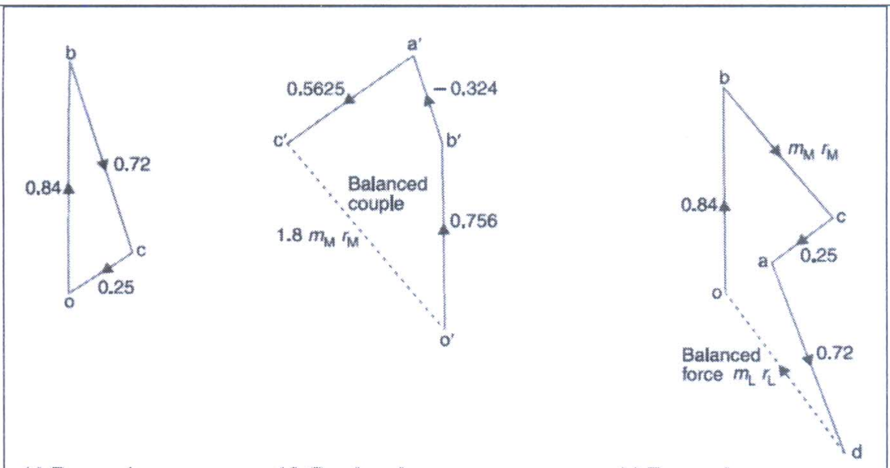
APPLYING (K3) **CO2** 2

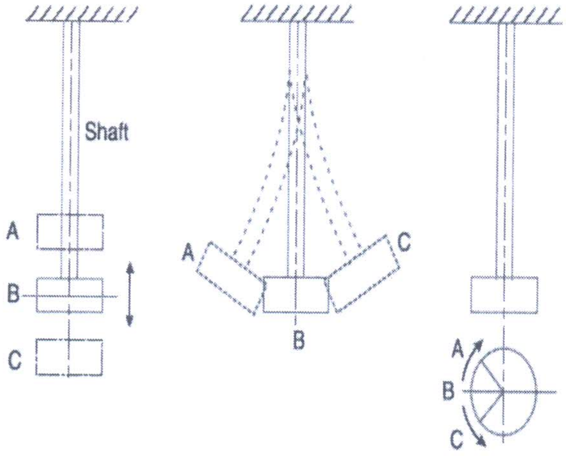


(*a*) Position of shaft and pulleys.

(*b*) Angular position of pulleys.

Plane (1)	Mass (m) kg (2)	Radius (r) m (3)	Cent. force ÷ ω^2 (m.r) kg-m (4)	Distance from plane L(l)m (5)	Couple ÷ ω^2 (m.r.l) kg-m^2 (6)
A	48	0.015	0.72	− 0.45	− 0.324
L(R.P)	m_L	r_L	$m_L.r_L$	0	0
B	56	0.015	0.84	0.9	0.756
M	m_M	r_M	$m_M.r_M$	1.8	1.8 $m_M.r_M$
C	20	0.0125	0.25	2.25	0.5625

	 (*c*) Force polygon. (*d*) Couple polygon. (*e*) Force polygon. Angle between pulleys *B* and *A* = 161° Ans. Angle between pulleys *A* and *C* = 76° Ans. Angle between pulleys *C* and *B* = 123° Ans. ∴ Dynamic force at the bearing *M* $= m_M.r_M.\omega^2 = 0.54\ (31.42)^2 = 533$ N Ans. ∴ Dynamic force at the bearing *L* $= m_L.r_L.\omega^2 = 0.54\ (31.42)^2 = 533$ N Ans. Out-of-balance couple = vector $o'c'$ = 0.97 kg-m^2 $= 0.97 \times \omega^2 = 0.97\ (31.42)^2 = 957.6$ N-m Dynamic force on each bearing $= \frac{\text{Out-of-balance couple}}{\text{Distance between bearings}} = \frac{957.6}{1.8} = 532$ N Ans.			
9.	1. *Free or natural vibrations.* When no external force acts on the body, after giving it an initial displacement, then the body is said to be under *free or natural vibrations.* The frequency of the free vibrations is called *free or natural frequency.* 2. *Forced vibrations.* When the body vibrates under the influence of external force, then the body is said to be under *forced vibrations.* The external force applied to the body is a periodic disturbing force created by unbalance. The vibrations have the same frequency as the applied force. Note : When the frequency of the external force is same as that of the natural vibrations, resonance takes place. 3. *Damped vibrations.* When there is a reduction in amplitude over every cycle of vibration, the motion is said to be *damped vibration.* This is due to the fact that a certain amount of energy possessed by the vibrating system is always dissipated in overcoming frictional resistances to the motion.	**ANALYZING (K4)**	**CO4**	2

10.	**1.** Longitudinal vibrations, **2.** Transverse vibrations, and **3.** Torsional vibrations.  *B* = Mean position ; *A* and *C* = Extreme positions. (*a*) Longitudinal vibrations. (*b*) Transverse vibrations. (*c*) Torsional vibrations.	**ANALYZING (K4)**	**CO4**	2

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Signature of Principal

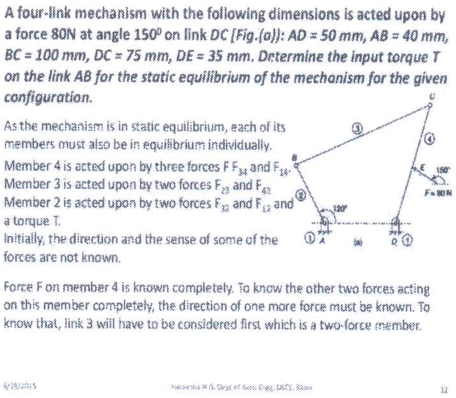
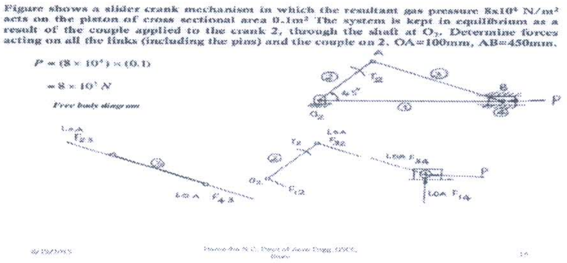
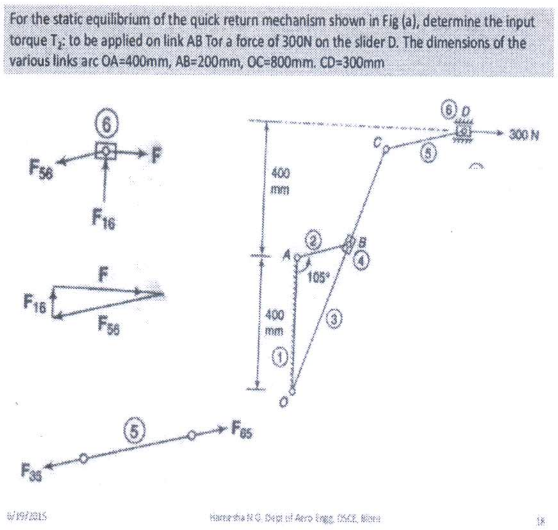
KSIT Bangalore

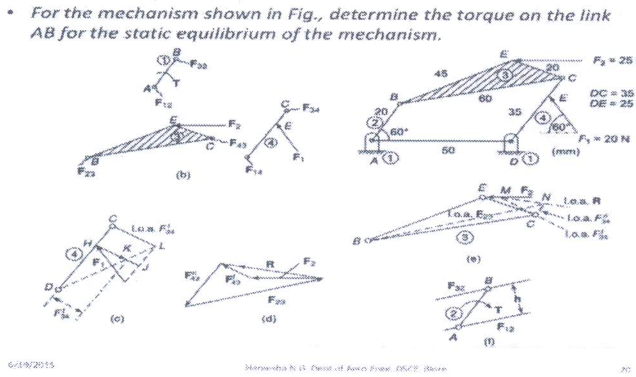
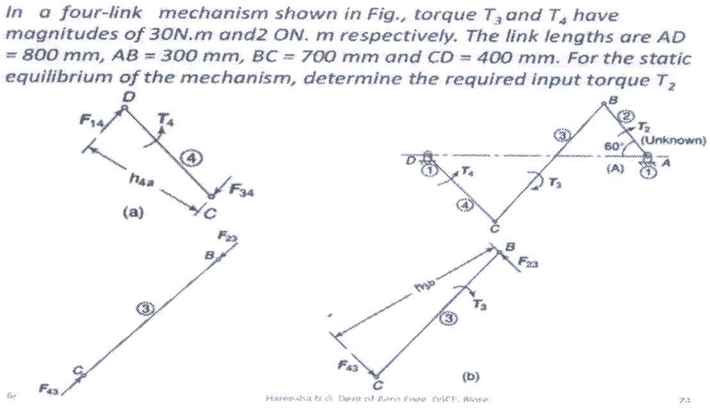
DEPARTMENT OF MECHANICAL ENGINEERING
ASSIGNMENT QUESTIONS

Academic Year	**2018-2019**		
Batch	**2016-2020**		
Year/Semester/section	**III/V/B**		
Subject Code-Title	**15ME52-DYNAMICS OF MACHINES**		
Name of the Instructor	**Mr.ANILKUMAR A**	**Dept**	**ME**

Assignment No: 2 **Total marks:20**
Date of Issue: 09.10.2018 **Date of Submission: 22.10.2018**

<table>
<tr><th>Sl. No.</th><th>Assignment Questions</th><th>K Level</th><th>CO</th><th>Marks</th></tr>
<tr><td>1.</td><td>A shaft carries four masses A, B, C and D of magnitude 200 kg, 300 kg, 400 kg and 200 kg respectively and revolving at radii 80 mm, 70 mm, 60 mm and 80 mm in planes measured from A at 300 mm, 400 mm and 700 mm. The angles between the cranks measured anticlockwise are A to B 45°, B to C 70° and C to D 120°. The balancing masses are to be placed in planes X and Y. The distance between the planes A and X is 100 mm, between X and Y is 400 mm and between Y and D is 200 mm. If the balancing masses revolve at a radius of 100 mm, Solve their magnitudes and angular positions.</td><td>APPLYING (K3)</td><td>CO2</td><td>2</td></tr>
<tr><td>2.</td><td>Four masses A, B, C and D as shown below are to be completely balanced.
<table>
<tr><th></th><th>A</th><th>B</th><th>C</th><th>D</th></tr>
<tr><td>Mass (kg)</td><td>—</td><td>30</td><td>50</td><td>40</td></tr>
<tr><td>Radius (mm)</td><td>180</td><td>240</td><td>120</td><td>150</td></tr>
</table>
The planes containing masses B and C are 300 mm apart. The angle between planes containing B and C is 90°. B and C make angles of 210° and 120° respectively with D in the same sense. Solve : The magnitude and the angular position of mass A ; and The position of planes A and D.</td><td>APPLYING (K3)</td><td>CO2</td><td>2</td></tr>
<tr><td>3.</td><td>Explain the condition of equilibrium for a body subjected to two forces, three forces and two forces and a torque.</td><td>UNDERSTANDING (K2)</td><td>CO3</td><td>2</td></tr>
<tr><td>4.</td><td>A four link mechanism with the following dimensions is acted upon by a force 80N at an angle 150 ° on link DC, AD=50mm, AB=40mm, BC=100mm, DC=75mm, DE=35mm. Calculate the input torque T on the link AB for the static equilibrium of the mechanism for the given configuration.</td><td>APPLYING (K3)</td><td>CO3</td><td>2</td></tr>
</table>

	 A four-link mechanism with the following dimensions is acted upon by a force 80N at angle 150⁰ on link *DC [Fig.(a)]: AD = 50 mm, AB = 40 mm, BC = 100 mm, DC = 75 mm, DE = 35 mm. Determine the input torque T on the link AB for the static equilibrium of the mechanism for the given configuration.* As the mechanism is in static equilibrium, each of its members must also be in equilibrium individually. Member 4 is acted upon by three forces F F_{34} and F_{14}. Member 3 is acted upon by two forces F_{23} and F_{43} Member 2 is acted upon by two forces F_{32} and F_{12} and a torque T. Initially, the direction and the sense of some of the forces are not known. Force F on member 4 is known completely. To know the other two forces acting on this member completely, the direction of one more force must be known. To know that, link 3 will have to be considered first which is a two-force member. 			
5.	Fig shows a slider crank mechanism in which the resultant gas pressure 8 x10⁴N/m² acts on the piston of cross sectional ares 0.1m². The system is kept in equilibrium as a resut of th couple applies to the crank 2, through the shaft ay o₂. **Find** the forces acting on all the links(including pins) and the couple on 2. O₂A=100mm, AB=450mm.  Figure shows a slider crank mechanism in which the resultant gas pressure 8x10⁴ N/m² acts on the piston of cross sectional area 0.1m² The system is kept in equilibrium as a result of the couple applied to the crank 2, through the shaft at O₂. Determine forces acting on all the links (including the pins) and the couple on 2. OA=100mm, AB=450mm. $P = (8 \times 10^4) \times (0.1)$ $= 8 \times 10^3 N$ Free body diagram 	APPLYING (K3)	CO3	2
6.	For the static equilibrium of the quick return mechanism shown in fig, **Obtain** the input torque T₂ to be applied on link AB for a force of 300N on the lsider D, the dimensions of the vrious links are OA=400mm, AB=200mm, OC=800mm, CD=300mm  For the static equilibrium of the quick return mechanism shown in Fig (a), determine the input torque T_2 to be applied on link AB Tor a force of 300N on the slider D. The dimensions of the various links arc OA=400mm, AB=200mm, OC=800mm. CD=300mm 	APPLYING (K3)	CO3	2
7.	a) For the mechanism shown in fig, **Determine** the torque on the link AB for the static equilibrium of the mechanism.	APPLYING (K3)	CO3	1

	 For the mechanism shown in Fig., determine the torque on the link AB for the static equilibrium of the mechanism. 6/19/2015 Hareesha N G, Dept of Aero Engg, DSCE, Blore b) In a four link mechanism sown in fig, torque T3 and T4 have magnitudes of 30N-m and 20N-m respectively. The link lengths are AD=800mm, AB=300mm, BC=700mm and CD=400mm, for the static equilibrium of the mechanism, **determine** the required input torque T2.  In a four-link mechanism shown in Fig., torque T_3 and T_4 have magnitudes of 30N.m and2 ON. m respectively. The link lengths are AD = 800 mm, AB = 300 mm, BC = 700 mm and CD = 400 mm. For the static equilibrium of the mechanism, determine the required input torque T_2 Hareesha N G, Dept of Aero Engg, DSCE, Blore			1
8.	Define Damping and **explain** different types of damping	APPLYING (K3)	CO5	2
9.	**Establish** the differential equation of damped free vibration	ANALYZING (K4)	CO5	2
10.	**Make use of** differential equation of damped free vibration to define damping coefficient and damping ratio	APPLYING (K3)	CO5	2

Signature of course in charge

Signature of Module Coordinator

signature of HOD/ME

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Signature of Chief Academic Coordinator

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2/11/18

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DEPARTMENT OF MECHANICAL ENGINEERING

Scheme

Academic Year	**2018-2019**		
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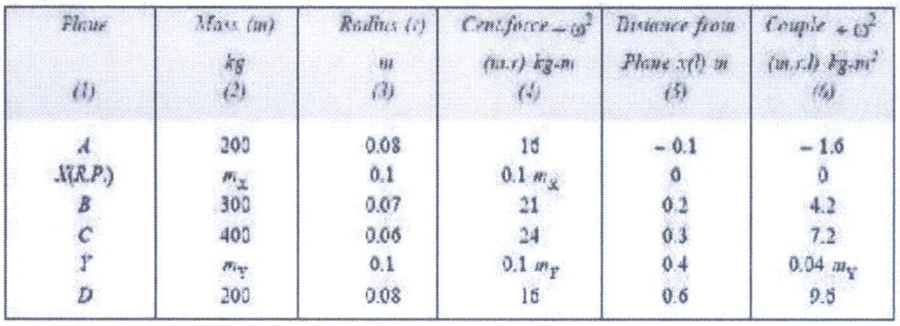
Subject Code-Title	**15ME52-DYNAMICS OF MACHINES**		
Name of the Instructor	**Mr. ANILKUMAR A**	**Dept**	**ME**

Assignment No: 1 **Total marks:20**

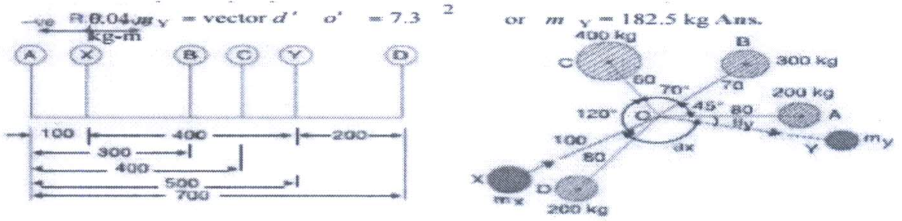
Date of Issue: 09.10.2018 **Date of Submission: 22.10.2018**

Sl.No	**Assignment Questions**	**K Level**	**CO**	**Marks**
1.	Given : m_A = 200 kg ; m_B = 300 kg ; m_C = 400 kg ; m_D = 200 kg ; r_A = 80 mm =0.08m ,r_B = 70 mm = 0.07 m ; r_C = 60 mm = 0.06 m ; r_D = 80 mm = 0.08 m ; $r_X = r_Y$ = 100 mm = 0.1 m Let m_X = Balancing mass placed in plane *X*, and m_Y = Balancing mass placed in plane *Y*.	APPLYING (K3)	**CO1**	2



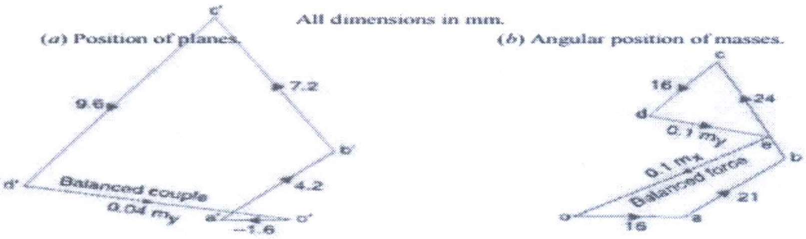
Plane (1)	Mass (m) kg (2)	Radius (r) m (3)	Cent.force ÷ ω^2 (m.r) kg-m (4)	Distance from Plane x(l) m (5)	Couple ÷ ω^2 (m.r.l) kg-m^2 (6)
A	200	0.08	16	− 0.1	− 1.6
X(R.P.)	m_X	0.1	0.1 m_X	0	0
B	300	0.07	21	0.2	4.2
C	400	0.06	24	0.3	7.2
Y	m_Y	0.1	0.1 m_Y	0.4	0.04 m_Y
D	200	0.08	16	0.6	9.6

R 0.04 m_Y = vector $d'o'$ = 7.3 kg-m^2 or m_Y = 182.5 kg Ans.



All dimensions in mm.

(*a*) Position of planes. (*b*) Angular position of masses.



(*c*) Couple polygon. (*d*) Force polygon

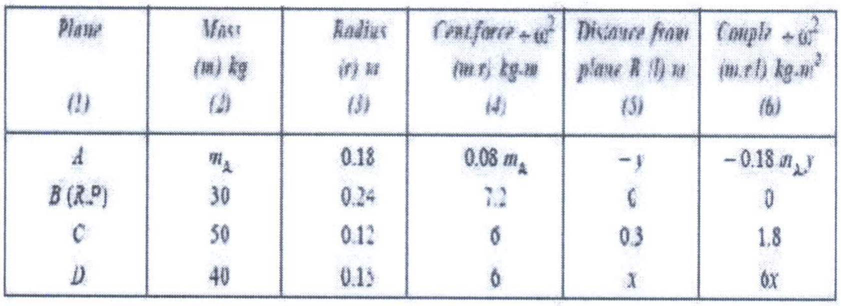
By measurement, the angular position of m_Y is $\theta_Y = 12^o$in the clockwise direction from mass m_A(*i.e.* 200 kg). **Ans.**

Bymeasurement,0.1 m_X = vector *eo* = 35.5kgm or m_X = **355 kg**

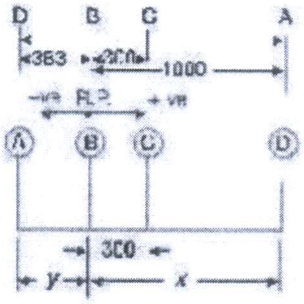
By measurement, the angular position of m_X is $\theta_X = 145^o$ in the clockwise direction from mass m_A(*i.e.* 200 kg). **Ans.**

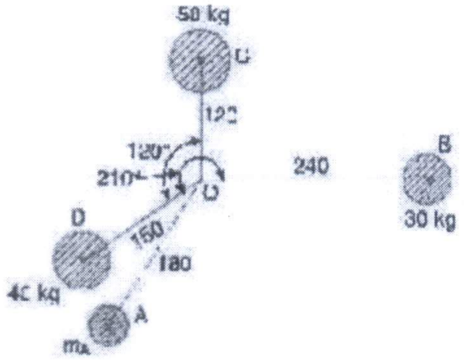
2.

Given : $r_A = 180$ mm = 0.18 m ; $m_B = 30$ kg ; $r_B = 240$ mm = 0.24 m ; $m_C = 50$ kg ; $r_C = 120$ mm = 0.12 m ; $m_D = 40$ kg ; $r_D = 150$ mm = 0.15 m ; ∠ $BOC = 90°$; ∠ $BOD = 210°$; ∠ $COD = 120°$



Plane (1)	Mass (m) kg (2)	Radius (r) m (3)	Cent.force ÷ ω^2 (m.r) kg.m (4)	Distance from plane B (l) m (5)	Couple ÷ ω^2 (m.r.l) kg.m^2 (6)
A	m_A	0.18	0.08 m_A	− y	− 0.18 m_A.y
B (R.P)	30	0.24	7.2	0	0
C	50	0.12	6	0.3	1.8
D	40	0.15	6	x	6x





By measurement,

0.18 mA = Vector do = 3.6 kg-m or mA = 20 kg Ans.

angular position of mass A from mass B in the anticlockwise direction is ∠ AOB = 236° Ans.

6 x = vector c'd' = 2.3 kg-m2 or x = 0.383 m

couple polygon that the direction of vector *c' d'* is opposite to the direction of mass *D*. Therefore the plane of mass *D* is 0.383 m or 383 mm towards left of plane *B* and not towards right of plane *B* as already assumed. **Ans.**

$$0.18\ m_A.y = \text{vector } o'\ d' = 3.6 \text{ kg-m}^2$$

$$-\,0.18 \times 20\ y = 3.6 \text{ or } y = -\,1 \text{ m}$$

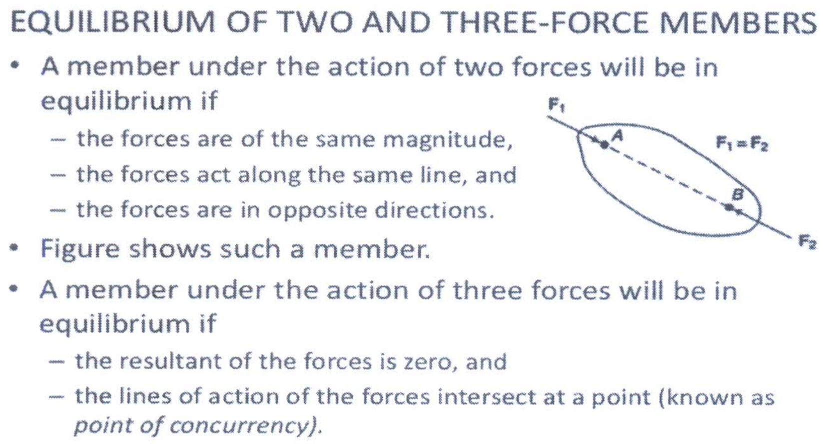
The negative sign indicates that the plane *A* is not towards left of *B* as assumed but it is 1 m or 1000 mm towards right of plane*B*. **Ans.**

APPLYING (K3)

CO1

2

3.



EQUILIBRIUM OF TWO AND THREE-FORCE MEMBERS

- A member under the action of two forces will be in equilibrium if
  - the forces are of the same magnitude,
  - the forces act along the same line, and
  - the forces are in opposite directions.
- Figure shows such a member.
- A member under the action of three forces will be in equilibrium if
  - the resultant of the forces is zero, and
  - the lines of action of the forces intersect at a point (known as *point of concurrency).*

UNDERSTANDING

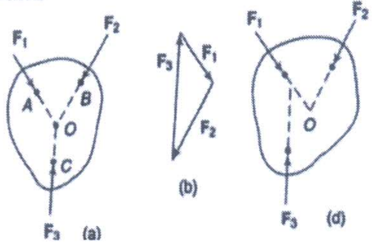
(K2)

CO1

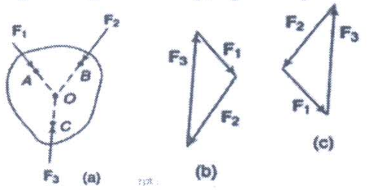
2

EQUILIBRIUM OF TWO AND THREE-FORCE MEMBERS (Contd….)

- Figure (a) shows a member acted upon by three forces F_1, F_2 and F_3 and is in equilibrium as the lines of action of forces intersect at one point *O and the resultant is zero.*
- *This is verified by adding the forces vectorially [Fig.(b)].*
- *As the head of the last vector F_3 meets the tail of the first vector F_1, the resultant is zero.*
- Figure (d) shows a case where the magnitudes and directions of the forces are the same as before, but the lines of action of the forces do not intersect at one point.
- Thus, the member is not in equilibrium.

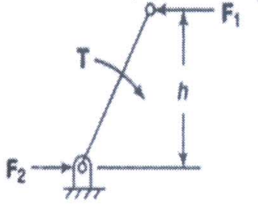


- Consider a member in equilibrium in which force F_1 *is completely known,* F_2 *known in direction only and* F_3 *completely unknown.*
- *The point of applications of F_1, F_2 and F_3 are A, B and C respectively.*
- *To solve such a problem, first find the point of concurrency O from the two forces with known directions, i.e. from F_1, and F_2.*
- *Joining O with C gives the line of action of the third force F_3.*
- *To know the magnitudes of the forces F_2 and F_3, take a vector of proper magnitude and direction to represent the force F_1.*
- *From its two ends, draw lines parallel to lines of action of the forces F_2 and F_3 forming a force triangle [Fig.].*
- *Mark arrowheads on F_2 and F_3 so that F_1, F_2 and F_3 are in the same order.*



MEMBER WITH TWO FORCES AND A TORQUE

- A member under the action of two forces and an applied torque will be in equilibrium if
  - the forces are equal in magnitude, parallel in direction and opposite in sense and
  - the forces form a couple which is equal and opposite to the applied torque.

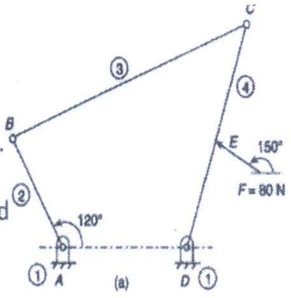
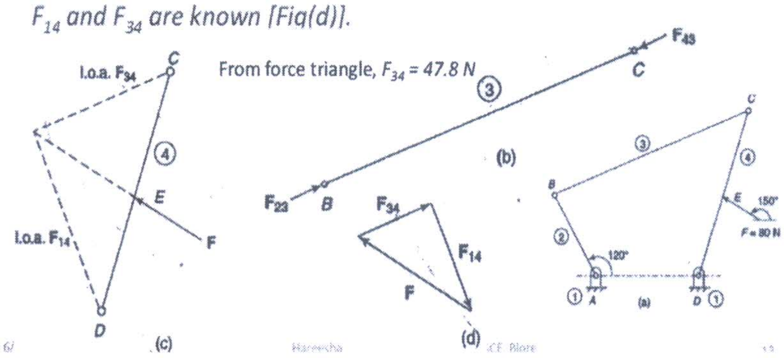
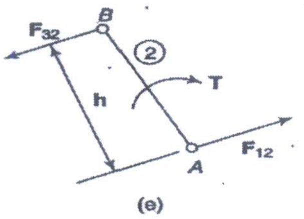
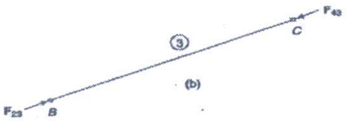
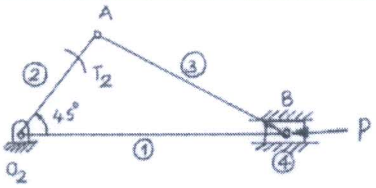
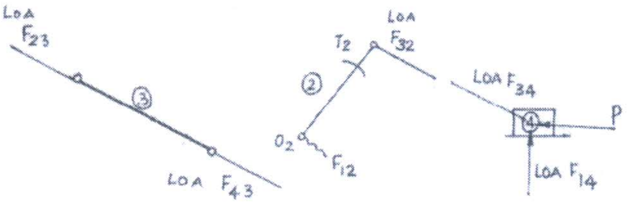


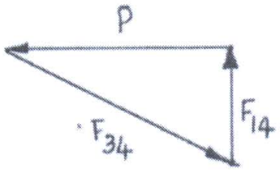
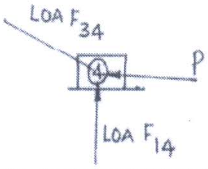
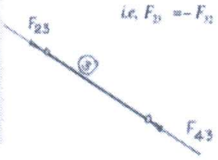
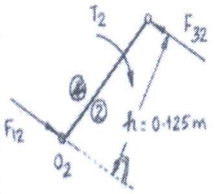
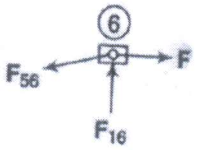
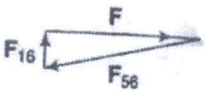
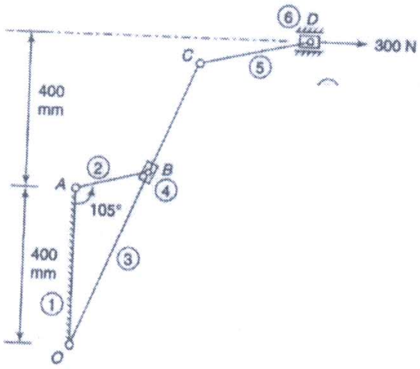
- Figure shows a member acted upon by two equal forces **F_1**, and **F_2** and an applied torque **T** for equilibrium,

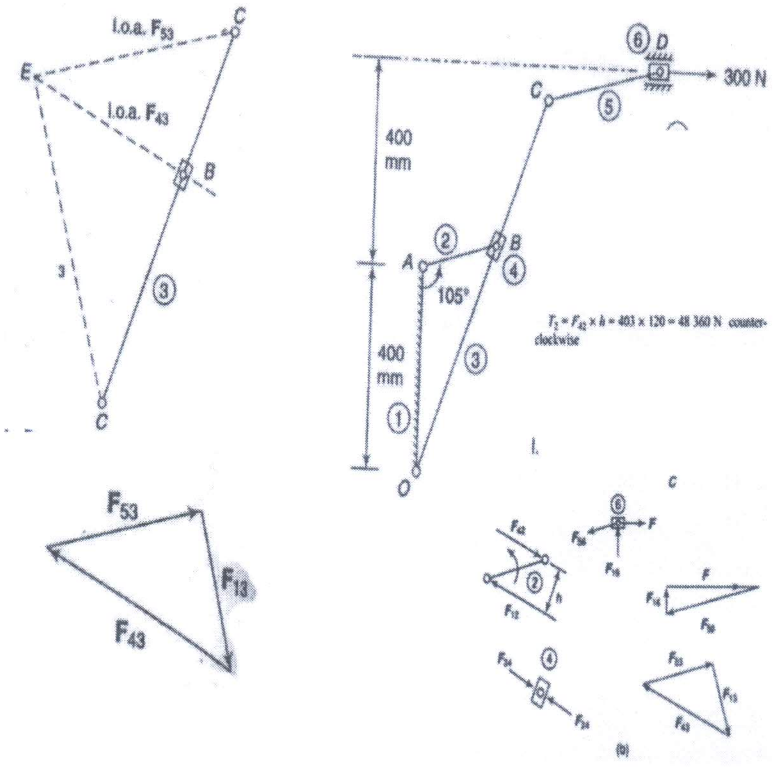
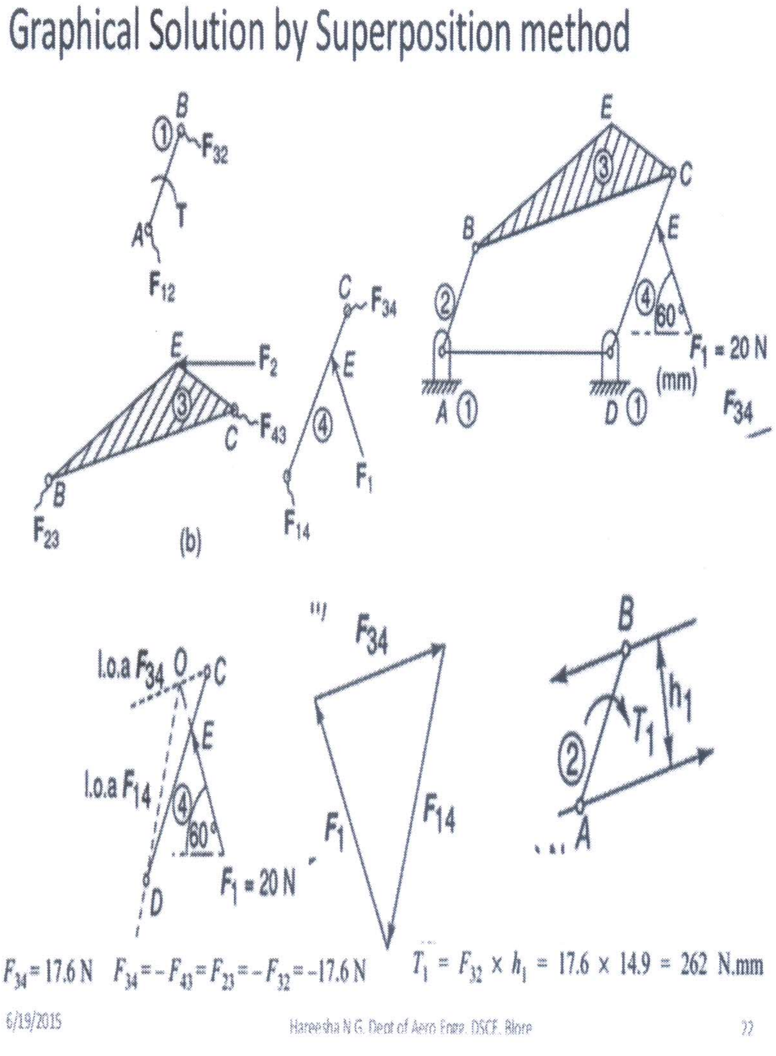
$$T = F_1 \times h = F_2 \times h$$

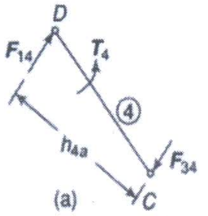
where *T, F_1 and F_2 are the magnitudes of T, F_1 and* F_2 respectively.

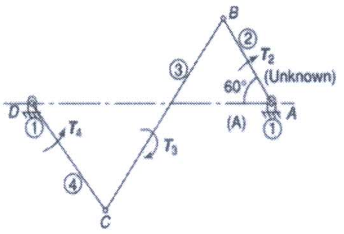
- **T** is clockwise whereas the couple formed by **F_1**, and **F_2** is counter-clockwise.

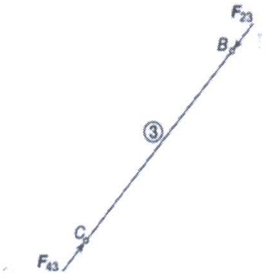
4.	***configuration.***  As the mechanism is in static equilibrium, each of its members must also be in equilibrium individually. Member 4 is acted upon by three forces F F_{34} and F_{14}. Member 3 is acted upon by two forces F_{23} and F_{43} Member 2 is acted upon by two forces F_{32} and F_{12} and a torque T. Initially, the direction and the sense of some of the forces are not known. Force F on member 4 is known completely. To know the other two forces acting on this member completely, the direction of one more force must be known. To know that, link 3 will have to be considered first which is a two-force member. - As link 3 is a two-force member [Fig.(b)], for its equilibrium, F_{23} and F_{43} must act along *BC (at this stage, the sense of direction of forces F_{23} and F_{43} is not known). Thus, the line of action of F_{34} is also along BC.* - As force F_{34} acts through point C on link 4, draw a line parallel to *BC through C by taking a free body of link 4 to represent the same. Now, as link 4 is three force member, the third force F_{14} passes through the intersection of F and F_{34} [Fig (c)].* - *By drawing a force triangle (F is completely known), magnitudes of F_{14} and F_{34} are known [Fig(d)].*  From force triangle, $F_{34} = 47.8$ N - Now, $F_{34} = -F_{43} = F_{23} = -F_{32}$ - Member 2 will be in equilibrium [Fig. (e)] if F_{12} is equal, parallel and opposite to F_{32} and *$T = -F_{32} \times h = 47.8 \times 39.3 = -1878.54$ N.mm The input torque has to be equal and opposite to this couple i.e. T= 1878.5 N/mm (clockwise)* h=Perpendicular distance between two equal and opposite forces.   	APPLYING (K3)	**CO1**	2
5.	$P = (8 \times 10^4) \times (0.1)$ $= 8 \times 10^3\ N$ *Free body diagram*   	APPLYING (K3)	**CO1**	2

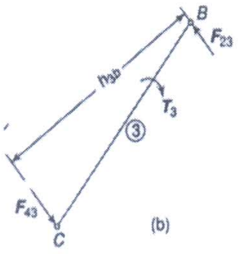
	Force triangle for the forces acting on(4)is drawn to some suitable scale. Magnitude and direction of P known and lines of action of F_{34} & F_{14} known.   $F_{34} = 8.8 \times 10^3$ N Measure the lengths of vectors and multiply by the scale factor to get the magnitudes of F_{14} & F_{34}. Directions are also fixed. Since link 3 is acted upon by only two forces, F_{43} and F_{23} are collinear, equal in magnitude and opposite in direction *i.e.*, $F_{43} = -F_{23} = 8.8x10^3$ N Also, $F_{23} = -F_{32}$ (equal in magnitude and opposite in direction). *i.e.* $F_{23} = -F_{32}$  Link 2 is acted upon by 2 forces and a torque, for equilibrium the two forces must be equal, parallel and opposite and their sense must be opposite to T_2. There fore, $F_{32} = -F_{12} = 8.8x10^3$ N  F_{32} & F_{12} form a counter clock wise couple of magnitude, $F_{23} * h = F_{12} * h$ $=(8.8x10^3)x0.125 = 1100$ Nm. To keep 2 in equilibrium, T: should act clockwise and magnitude is 1100 Nm. Note: h is measured perpendicular to F_{32} & F_{12}			
6.	    	APPLYING (K3)	**CO2**	2

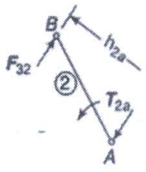
				
7.	Graphical Solution by Superposition method $F_{34} = 17.6$ N $F_{34} = -F_{43} = F_{23} = -F_{32} = -17.6$ N $T_1 = F_{32} \times h_1 = 17.6 \times 14.9 = 262$ N.mm 6/19/2015 Hareesha N G, Dept of Aero Engg, DSCE, Blore 22	APPLYING (K3)	**CO2**	2

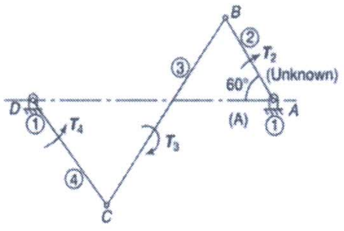


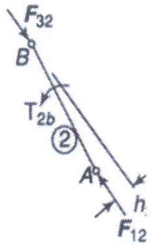












Neglecting torque T3

Torque $\mathbf{T}_4$ on the link 4 is balanced by a couple having two equal, parallel and opposite forces at *C* and *D*. As the link 3 is a two-force member, $\mathbf{F}_{43}$ and therefore, $\mathbf{F}_{34}$ and $\mathbf{F}_{14}$ will be parallel to *BC*.

$$F_{34} = F_{14} = \frac{T_4}{h_{4a}} = \frac{20}{0.383} = 52.2 \text{ N}$$

and $F_{34} = F_{43} = F_{23} = F_{32} = F_{12} = 52.2$ N

$T_{2a} = F_{32} \times h_{2a} = 52.2 \times 0.274 = 14.3$ N.m counter-clockwise.

Neglecting torque T4

$\mathbf{F}_{43}$ is along *CD*. The diagram is self-explanatory.

$$F_{43} = F_{23} = \frac{T_3}{h_{3b}} = \frac{30}{0.67} = 44.8 \text{ N}$$

$F_{23} = F_{32} = F_{12} = 44.8$ N

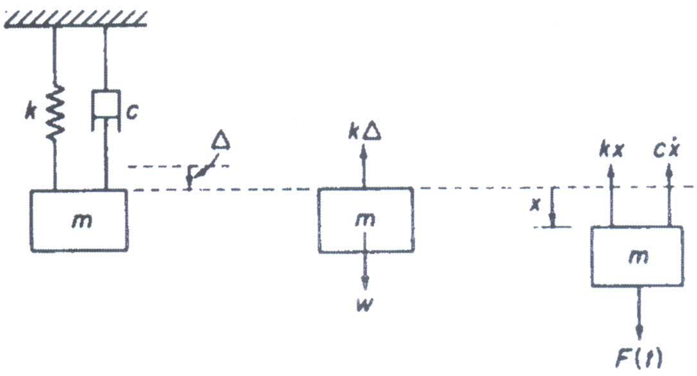
$T_{2b} = F_{32} \times h_{2b} = 44.8 \times 0.042 = 1.88$ N.m

counter-clockwise.

$T_2 = T_{2a} + T_{2b} = 14.3 + 1.88 = \underline{16.18 \text{ N}}$

counter-clockwise

8.	The resistance offered by a body to the vibratory motion is called **damping**	**APPLYING (K3)**	**CO2**	2

	Types of damping: a)Viscous damping b)dry friction or coulomb damping c) solid or structural damping d) slip or interfacial damping			
9.	 $x=e^{-(c/2m)t}\left(Ae^{\left(\sqrt{(c/2m)^2-k/m}\right)t}+Be^{-\left(\sqrt{(c/2m)^2-k/m}\right)t}\right)$	ANALYZING (K4)	CO4	2
10.	$x=e^{-(c/2m)t}\left(Ae^{\left(\sqrt{(c/2m)^2-k/m}\right)t}+Be^{-\left(\sqrt{(c/2m)^2-k/m}\right)t}\right)$ The behavior of the terms in the parentheses, however, depends on whether the numerical value within the radical is positive, zero, or negative. In the limiting case between the oscillatory and non oscillatory motion $(c/2m)^2=k/m$, and the radical is zero. The damping corresponding to this case is called critical damping, cc. $c_c = 2m\sqrt{\frac{k}{m}} = 2m\,\omega_n = 2\sqrt{km}$ Any damping can then be expressed in terms of the critical damping by a non dimensional number z , called the ***damping ratio***: $\zeta=\frac{c}{c_c}$	APPLYING (K3)	CO4	2

Signature of course in charge

Signature of Module Coordinator

K. Rama

signature of HOD/ME

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Signature of Chief Academic Coordinator

ACADEMIC CO-ORDINATOR
K.S. Institute of Technology
Bengaluru - 560 109.

2.11.18

Signature of Principal

DYNAMICS OF MACHINERY IA MARKS AND AVERAGE
AUGUST-2018 TO DECEMBER-2018

SI.NO	USN	NAME OF THE STUDENT	INTERNAL MARKS			AVERAGE IA
			IA-1	IA-2	IA-3	
1	1KS16ME057	PAVITHRA.B	15	AB	16	16
2	1KS16ME081	SHIVARAJ.N.S	13	14	19	17
3	1KS16ME082	SHIVASHANKAR.B.M	20	16	19	20
4	1KS16ME083	SIRISH GOVARDHAN	13	11	AB	12
5	1KS16ME084	SOWJANYA.D	15	17	18	18
7	1KS16ME085	SREEKARA.K.B	AB	20	20	20
8	1KS16ME086	SUDARSHAN.T	15	13	18	17
9	1KS16ME087	SUDHARSHAN.M.D	8	1`2	18	15
10	1KS16ME089	SUMESH.R	11	15	16	16
11	1KS16ME090	SUPREETH.K.R	12	14	19	17
12	1KS16ME093	VARUN.C	13	14	15	15
13	1KS16ME094	VASANTH KUMAR.S	13	14	17	16
14	1KS16ME095	VIJAYA KUMAR.M.S	15	14	18	17
15	1KS16ME096	VIJAYKUMARNAIK.T.C	AB	13	18	16
16	1KS16ME097	VINAY.B.V	15	12	15	15
17	1KS16ME098	VINAY.V.P	10	AB	17	14
18	1KS16ME099	VINITH.P	6	8	17	13
19	1KS16ME100	VITHAN.T.R	15	14	13	15
20	1KS16ME101	ABHIJITH.C	16	16	AB	16
21	1KS16ME102	MADHU.G.K	14	16	6	15
22	1KS16ME104	RAGHU.S	7	12	11	12
23	1KS16ME105	RAKESH.B.R	10	10	15	13
24	1KS17ME401	ARUNKUMAR.E	AB	9	15	12
25	1KS17ME402	ARUN KUMAR.R	17	10	AB	14
26	1KS17ME404	CHETHAN.C.R	AB	15	10	13
27	1KS17ME405	DARSHAN.H.R	12	14	14	14
28	1KS17ME406	DEEPAK.E	16	10	12	14
29	1KS17ME407	DEVIPRASAD.M	AB	13	13	13
30	1KS17ME408	GUHAN BHASKAR	10	14	14	14
31	1KS17ME409	GURUPRASAD.T.M	6	17	13	15
32	1KS17ME410	GURUSWAMY.H	10	13	16	15
33	1KS17ME411	JEEVAN ABHISHEK	16	13	20	18
34	1KS17ME412	KANTHARAJU.K.N	AB	13	14	14
35	1KS17ME413	KIRAN.S	8	8	15	12
36	1KS17ME415	LOHITH.R	11	14	13	14

37	1KS17ME416	MAHADEVA RAJU.H.E	8	10	16	13
38	1KS17ME417	MAHESH.D	AB	12	12	12
39	1KS17ME418	MANISH.N.D	14	14	13	14
40	1KS17ME419	MITHUN.S	10	AB	14	12
41	1KS17ME420	MOHAN KUMAR.C	13	16	17	17
42	1KS17ME421	MOHAN KUMAR.K	14	12	AB	13
43	1KS17ME422	NAGESH.S	13	12	AB	13
44	1KS17ME423	NIKHIL GOWDA.N.S	13	11	14	14
45	1KS17ME425	PRATAP.L	12	17	13	15
46	1KS17ME426	PRATHEEK.P	AB	11	12	12
47	1KS17ME430	RAKESH.B.R	AB	9	15	12
48	1KS17ME431	RAKSHITH.L	15	12	16	16
49	1KS17ME432	RAVI.K.R	AB	9	14	12
50	1KS17ME434	SHASHANK.Y.K	9	10	13	12
51	1KS17ME435	SHASHIKUMAR.C.R	14	11	16	15
52	1KS17ME437	SRINIVASA.B.V	15	14	16	16
53	1KS17ME439	SURABHI.N	11	13	10	12
54	1KS17ME440	SUSHMA.Y.S	15	16	18	17
55	1KS17ME441	TEJAS.P.N	13	13	14	14
56	1KS17ME442	THRIVENI.M	11	14	16	15
57	1KS17ME444	VINAY.S	14	12	15	15
58	1KS16ME401	AKSHAY S ARIKERIMAT	6	11	16	14
59	1KS16ME403	ANAND L H	11	14	12	13
60	1KS16ME408	HANAMANTAPPA	6	11	13	12
61	1KS16ME412	MOHAN SANGLE	7	8	16	12
62	1KS16ME424	ROHIT V RAO	10	11	12	12
63	1KS16ME429	SOWMYA B	12	12	11	12
64	1KS16ME438	VISHWANATH B NAYAK	14	11	15	15
65	1KS14ME030	PRASHANTH G	14	12	12	13
66	1KS15ME035	KIRANA C	7	7	AB	7
67	1KS15ME044	MITHUL KIRTHI J	10	10	15	13
68	1KS15ME053	PAVAN KUMAR REDDY	15	15	14	15
69	1KS16ME107	SUHAS Y	12	AB	12	12

Signature of Course incharge

Signature of HOD

DYNAMICS OF MACHINERY
LIST OF SLOW LEARNERS AUGUST-2018 TO DECEMBER-2018

SI.NO	USN	NAME OF THE STUDENT	INTERNAL MARKS			AVERAGE IA
			IA-1	IA-2	IA-3	
1	1KS16ME087	SUDHARSHAN.M.D	8	1`2	18	15
2	1KS16ME089	SUMESH.R	11	15	16	16
3	1KS16ME098	VINAY.V.P	10	AB	17	14
4	1KS16ME099	VINITH.P	6	8	17	13
5	1KS16ME104	RAGHU.S	7	12	11	12
6	1KS16ME105	RAKESH.B.R	10	10	15	13
7	1KS17ME408	GUHAN BHASKAR	10	14	14	14
8	1KS17ME409	GURUPRASAD.T.M	6	17	13	15
9	1KS17ME410	GURUSWAMY.H	10	13	16	15
10	1KS17ME413	KIRAN.S	8	8	15	12
11	1KS17ME415	LOHITH.R	11	14	13	14
12	1KS17ME416	MAHADEVA RAJU.H.E	8	10	16	13
13	1KS17ME434	SHASHANK.Y.K	9	10	13	12
14	1KS17ME439	SURABHI.N	11	13	10	12
15	1KS17ME442	THRIVENI.M	11	14	16	15
16	1KS16ME401	AKSHAY S ARIKERIMAT	6	11	16	14
17	1KS16ME403	ANAND L H	11	14	12	13
18	1KS16ME408	HANAMANTAPPA	6	11	13	12
19	1KS16ME412	MOHAN SANGLE	7	8	16	12
20	1KS16ME424	ROHIT V RAO	10	11	12	12
21	1KS15ME035	KIRANA C	7	7	AB	7
22	1KS15ME044	MITHUL KIRTHI J	10	10	15	13

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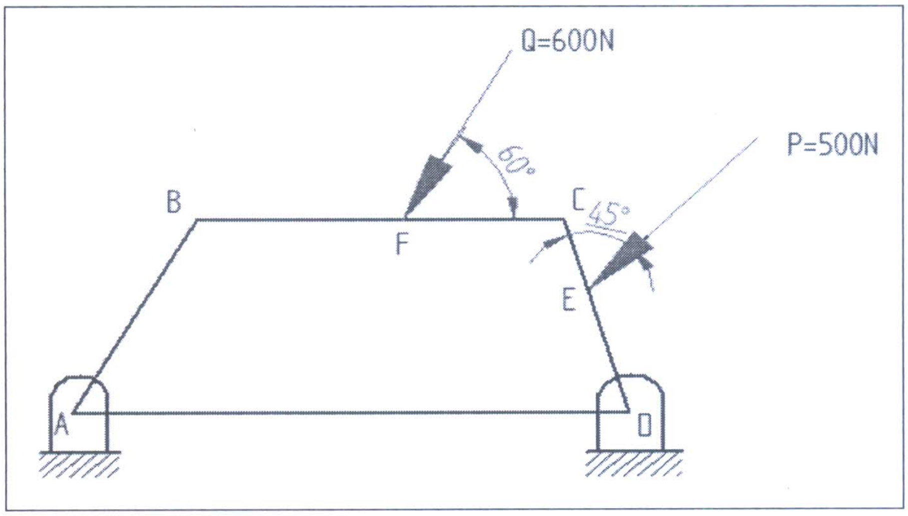
DEPARTMENT OF MECHANICAL ENGINEERING

Unit Wise Challenging Questions for Toppers

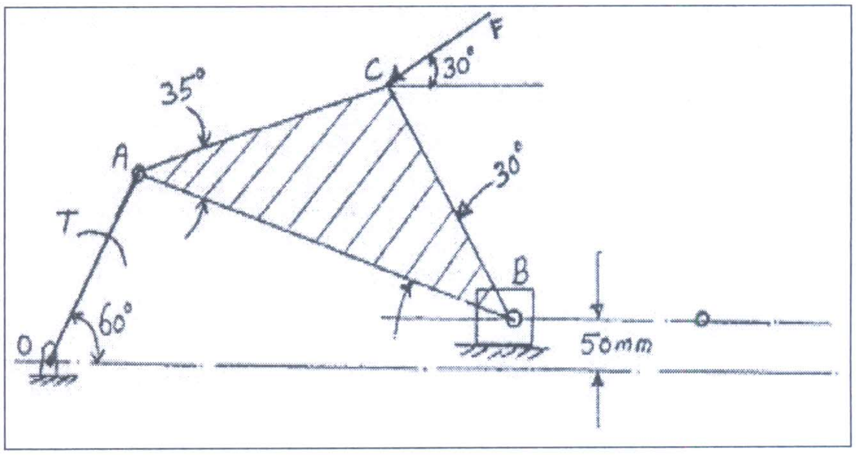
Academic Year	**2018-2019**		
Batch	**2016-2020**		
Year/Semester/section	**III/V/B**		
Subject Code-Title	**15ME52-DYNAMICS OF MACHINERY**		
Name of the Instructor	**Mr. A.ANILKUMAR**	**Dept**	**ME**

MODULE 1: (STATIC AND DYNAMIC FORCE ANALYSIS)

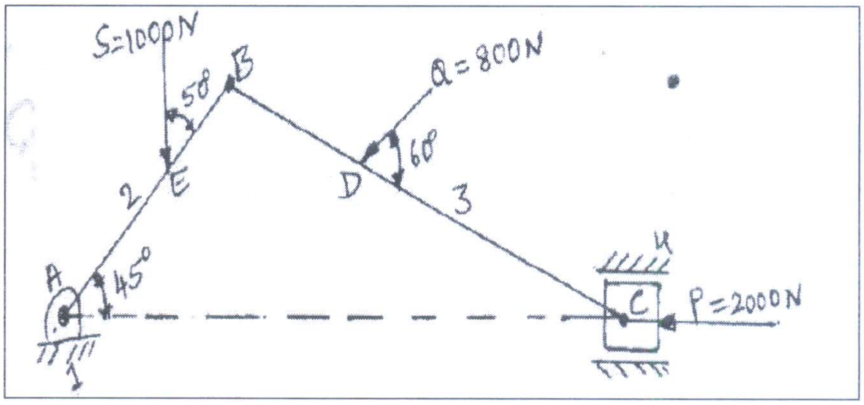
1. In the following figure four bar mechanism is shown. Calculate the required value of torque T_2 and various forces on the links for equilibrium of the mechanism. Take AB=50mm, BC=66mm, CD=55mm, CE=25mm, CF=30mm, BAD=60^0, AD=100mm.



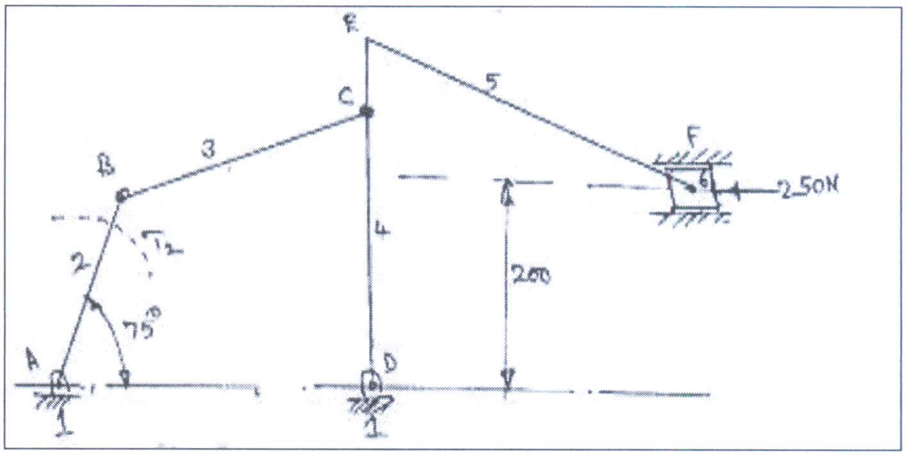
2. For the mechanism shown in figure find the required input torque for the static equilibrium. The lengths OA=250mm, AB=650mm and F=500N.



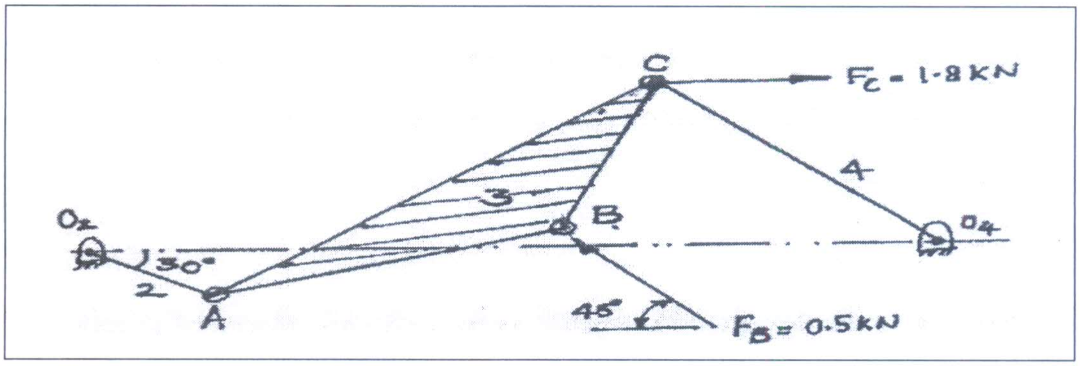
3. Determine the required torque T_2 for static equilibrium of the mechanism. Given AB=300mm, BC=600mm, BD=200mm, AE=200mm.



4. For the static equilibrium of the mechanism shown in figure, find the required input torque T_2. The dimensions are AB= 150mm, BC=AD=500mm, DC=300mm, CE=100mm, EF=450mm.



5. The following figure shows four bar linkage with force applied at points B and C. Draw free body diagram of each link and forces acting on each link. Find the required torque that must be applied to link 2 to maintain equilibrium. Take O_2A=75mm, AC=300mm, O_2O_4=400mm, O_4C=AB=200mm, BC=150mm.



6. The crank and connecting rod of a vertical single cylinder gas engine running at 1800rpm are 60mm and 240 mm respectively. The diameter of the piston is 80mm and the mass of the reciprocating is 1.2kg. At a point during the power stroke when the piston has moved 20mm from the top dead centre position, the pressure on the piston is 800KN/m^2. Determine:
   i) Net force on the piston.
   ii) Thrust in the connecting rod.
   iii) Thrust on sides of cylinder wall.
   iv) Engine speed at which above value is zero.

MODULE 2: (BALANCING OF ROTATING AND RECIPROCATING MASSES)

7. A Shaft is supported in bearings 1.8m apart and projects 0.45m beyond bearings at each end. The shaft carries three pulleys one at each end and one at the middle of its length. The mass of end pulleys are 48Kg and 20Kg and their centre of gravity are 15mm and 12.5mm respectively from the shaft axis. If the pulleys are so arranged as to give static balance. Determine:
   (i) The relative angular position of the pulleys.
   (ii) And Dynamic forces produced on the bearing when the shaft rotates at 300rpm.
8. A 3.6m long shaft carries three pulleys, two at its ends and the third at the midpoint. The two pulleys have masses 79Kg and 40Kg with their radii 3mm and 5mm from the axis of shaft respectively. The middle pulley has a mass of 50Kg with radius 8mm. The pulleys are so keyed to the shaft the assembly is in static balance. The shaft rotates at 300rpm in two bearings 2.4m apart with equal overhangs on either side. Determine:
   i) Relative angular positions of pulleys.
   ii) Dynamic reaction on the two bearings.
9. Four masses m_1=100kg, m_2=175kg, m_3=200kg, m_4=125kg are fixed to the crank of 200mm radius and revolve in planes 1st, 2nd, 3rd, respectively. The angular positions of the 2nd, 3rd, and 4th with respect to 1st plane are 75^0, 135^0 and 240^0 taken in the same sense. Distance of 2nd, 3rd and 4t planes from 1st plane are 600mm, 1800mm, 2400mm. Determine the magnitude and position of the balancing masses at the radius 600mm in planes L and M located in the middle of 1st and 2nd and in the middle of 3rd and 4th respectively.
10. A rotating shaft carries four masses A, B, C and D which are radially attached to it, along the shaft axis. The masses are 40mm, 50mm, 60mm and 70mm respectively from the axis of rotation. The masses B, C and D are 60Kg, 50Kg and 40Kg respectively. The angles of the masses C and D with respect to mass B are 90° and 210° in same sense, respectively. The planes containing B and C are 0.5m apart. For a complete balanced system, determine:
    i) The mass and angular position of mass A.
    ii) The position of planes containing masses A and D.
11. A rotating shaft carries four masses A=8Kg, B, C=6Kg, D=5kg. The mass centers are 30, 40, 40 and 50mm respectively from the axis of shaft. The axial distance between the planes of rotation of A and B is 400mm and between B and C is 500mm. The masses A and C are at right angles to each other. Find for a complete balance:
    i) The angle of the masses B and D from mass A
    ii) The axial distance between the planes of rotation of C and D
    iii) The magnitude of B
12. The firing order in a 6 cylinder vertical 4 stroke in line engine is 1-4-2-6-3-5. The stroke is 100mm and length of each connecting rod is 200mm. The pitch distances are 100mm, 100mm, 150mm, 100mm and 100mm respectively. The reciprocating mass per cylinder is 1kg and engine runs at 300rpm. Determine maximum magnitudes of secondary unbalanced forces and couples, choosing a plane midway between Cylinder 3 and 4 as the reference planes.
13. A four crank engine has the two outer cranks set at 120^0 to each other, and their reciprocating masses are each 400kg. The distance between the planes of rotation of adjacent cranks are 450mm, 750mm and 600mm. If the engine is to be in complete primary balance, find the reciprocating mass and their relative angular positions for each of the inner cranks. If the length of each crank is 300mm and length of connecting rod is 1.2m and the speed of rotation is 240rpm. What are the maximum secondary unbalanced forces?

MODULE 3: (GOVERNORS AND GYROSCOPES)

14. The arms of a Porter Governor are 200mm long and are hinged at a distance of 40mm from the axis of rotation. The mass of each ball is 1.5Kg and the sleeve is 2.5Kg.When the links are 30° to vertical the sleeve begins to raise at 260rpm .Assuming the friction force is constant, Find maximum and minimum speed when the inclination of the arm to the vertical is 45°.
15. The arms of a Porter Governor are 300mm long, the upper arms are pivoted on axis of rotation and lower arms are attached to the sleeve at a distance of 35mm from axis of rotation. The mass of sleeve is 54Kg and mass of each ball is 7Kg. Determine the equilibrium speed when radius of rotation of ball is 225mm.What will be range of speed if frictional force is equal to 30N at sleeve?
16. In a Porter Governor the upper and lower arms are 250mm long each and pivoted on axis of rotation. The mass of each rotating ball is 3Kg and mass of sleeve is 20Kg.The sleeve is in its lowest position when the arms are inclined at 30° to the governor axis. The lift of sleeve is 36mm. Find the force of friction at the sleeve if the speed at the moment it rises from lowest position is equal to speed at moment it falls from highest position. Also find range of governor.
17. A spring loaded governor of Hartnell type has arms of equal lengths. The weights rotate in a circle of 13cm diameter when the sleeve is in the mid position and the weight arm is vertical .The equilibrium speed for this position is 450rpm, neglecting friction. The maximum sleeve movement is to be 25mm & the maximum speed variation taking friction into account is to be ±5% of the mid position equilibrium speed .The weight of sleeve is 39N and the friction may be considered equivalent to 29N at the sleeve .The power of the governor must be sufficient to overcome the friction by 1% change of speed either way at mid position .Determine , neglecting obliquity effect,
    i) weight of each rotating mass
    ii) spring stiffness in N/m
    iii) Initial compression of spring.
18. The mass of each balls of Hartnell type Governor is 1.4Kg.The length of ball arm of the bell-crank leaver is 100mm whereas the length of arm towards sleeve is 50mm.The distance of fulcrum of the bell-crank leaver from the axis of rotation is 80mm. The extreme radii of rotation of the balls are 75mm and 112.5mm .The maximum equilibrium speed is 6% greater than the minimum equilibrium speed which is 300rpm. Determine
    i) stiffness of the spring and
    ii) Equilibrium speed when radius of rotation of the ball is 90mm. Neglect the obliquity effect.
19. Each wheel of a four wheeled, rear engine automobile has a moment of inertia 2.4kgm^2 and an effective diameter of 660mm. The rotating parts of an engine have an moment of inertia 1.2kgm^2. The gear ratio of the engine of the back wheel is 3 to 1. The engine axis is parallel to the rear axel and the crank shaft rotates in the same sense as the road wheels. The mass of the vehicle is 2200kg and the center of the mass is 550m above the road level. The track width of the vehicle is 1.5m. Determine the limiting speed of the vehicle around a curve with 80m radius so that all four wheels maintain contact with road surface.
20. A rear engine automobile is travelling along a track of 100m radius. Each of the four wheels has a moment of inertia 2kgm^2 and an effective diameter of 0.6m. The rotating parts of the engine have a moment of inertia of 1.25kgm^2. The engine axis is parallel to the rear axle and the crank shaft rotates in same direction as the wheels. The gear ratio of engine to back axel is 3:1. The automobile mass is 1500kg and its center of gravity is 0.5m above the road level. The track width of the vehicle is 1.5m. Determine the limiting speed of the vehicle around a curve for all four wheels to maintain contact with road surface.
21. The mass of a four wheeled car is 1200kg and its center of gravity is 0.6m above the ground and lies centrally with respect to the four wheels. Its track width is 1.5m and wheel base is 2m. The moment of inertia of each wheel is 3kg-m^2 and effective radius is 0.4m. The moment of inertia of rotating parts is 0.75kg-m^2 and rotates at 200rpm in clockwise direction when seen from front. The car takes right turn around a bend of 30m radius at a speed of 60kmph. Calculate the gyroscopic couple and centrifugal couple acting on the vehicle. Also calculate the road reaction on wheels.

MODULE 4: (INTRODUCTION TO VIBRATIONS AND UNDAMPED FREE VIBRATIONS)

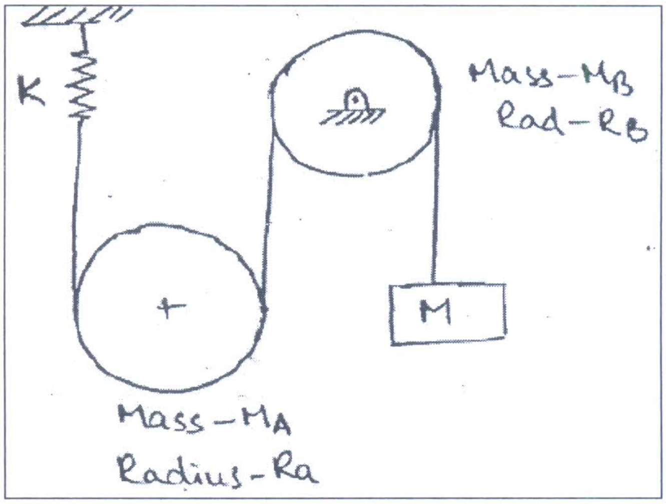
22. Add the following two harmonic waves analytically and check the solution graphically.

$$\boxed{X_1 = 3\sin\left(\omega t + \frac{\pi}{6}\right) \, and \, X_2 = 4\,\text{Cos}\left(\omega t + 10^0\right)}$$

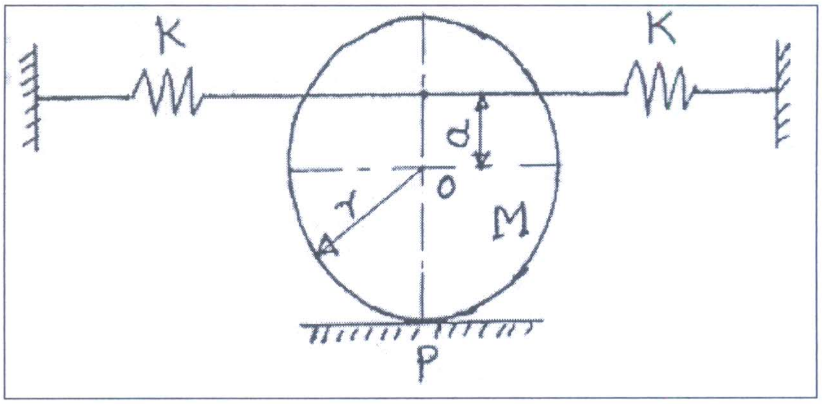
23. Split the given harmonic motion in to two harmonic motions, one having a phase angle of zero and the other of 45^0. Use both analytical and graphical method.

$$\boxed{X = 10\,\sin(\omega t + \frac{\pi}{6})}$$

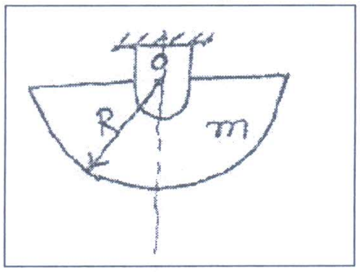
24. An unknown weight W, added to an unknown spring K has a natural frequency of 95 cycles/min. When 5N is added to W , natural frequency is lowered to 75 cycles/min. Determine the unknown weight and the spring constant.
25. Split X(t) = 5 Sin(ωt+30^0) into two simple harmonic motions, one with 60^0 phase lead and other with 45^0 phase lag.
26. Find the natural frequency of the mass.



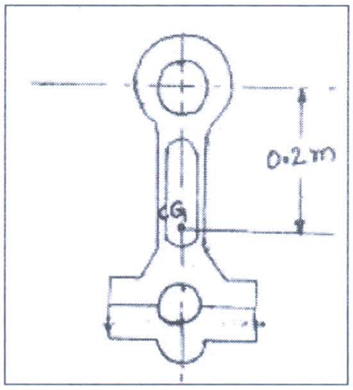
27. Find out the natural frequency of the system shown in figure using Newton's method and energy method.



28. A semi circular disc of radius R and mass m is pivoted freely about the center as shown in figure. Determine natural frequency of oscillation for small displacement. Use energy method.

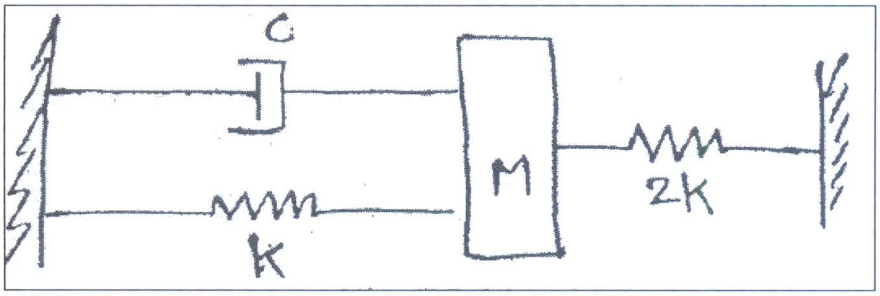


29. The connecting rod shown in figure is supported at the wristpin end. It is displaced and allowed to oscillate. The mass of the rod is 5kg and the center of gravity is 0.2m from the pivot point O. If the frequency of oscillation is 40 cycles/minute, calculate moment of inertia of the system about is center of gravity.



MODULE 5: (DAMPED FREE VIBRATIONS & FORCED VIBRATIONS)

30. A spring mass damper system consisting of mass 10kg and springs of stiffness 250N/m and Damper of damping coefficient 15Ns/m. Determine Damping factor, Critical damping coefficient, logarithmic decrement, Ratio of two consecutive amplitudes. Also find number of cycles after which the initial amplitude is reduced to 15%.
31. What is the value of C such that the system shown in figure if critically damped if M=10kg, K=5KN/m.



32. Vibration system consisting of mass 3kg and springs of stiffness 100KN/m and Damper of damping coefficient 30Ns/m. Determine Damping factor, Critical damping coefficient, logarithmic decrement, Ratio of two consecutive amplitudes. Also find number of cycles after which the initial amplitude is reduced to 20%.
33. An air compressor of 450 kg operates at constant speed of 1750rpm. The reciprocating part is 10kg and crank radius is 100mm. Specify the spring for the mounting such that only 20% of the unbalanced forced is transmitted to the foundation when
    i) Damping ratio ξ=0
    ii) Damping ratio ξ= 0.15
34. A 40kg fan has a rotating unbalance of magnitude 0.1 kgm. The fan is mounted on the free end of a cantilever beam of length 1.2m. Find steady state amplitude of the fan when it operates at 1000rpm. The young's modulus of elasticity of the beam material is 200Gpa and moment of inertia is 1.3×10^{-6} m^4. The beam is specially treated to add viscous damping of ξ=0.0617.
35. A single cylinder vertical petrol engine has a total mass of 320kg is mounted upon a steel chassis frame and causes a vertical static deflection of 0.2cm. The reciprocating parts of the engine have a mass of 24kg and move through vertical stroke of 15cm with SHM. A dashpot is provided, the damping resistance of which is directly proportional to velocity and amounts to 490N at 0.3m/s. Determine
    i) Speed of driving shaft at which resonance will occur.
    ii) The amplitude of steady state forced vibrations when driving shaft of engine rotated at 480rpm.

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CBCS Scheme

USN ☐☐☐☐☐☐☐☐☐☐ **15ME52**

Fifth Semester B.E. Degree Examination, Dec.2017/Jan.2018

Dynamics of Machinery

Time: 3 hrs. Max. Marks: 80

Note: Answer any FIVE full questions, choosing one full question from each module.

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-1

1 a. Explain the equilibrium with respect to two force of three force member. **(02 Marks)**

b. A four link mechanism with the following dimensions is acted upon by a force 80N 150° on the link DC. Determine the input torque on the link AB for the static equilibrium of the mechanism for the given configuration. AB = 400mm ; BC = 1000mm, CD = 750mm and DE = 350mm, AD = 500mm. **(14 Marks)**

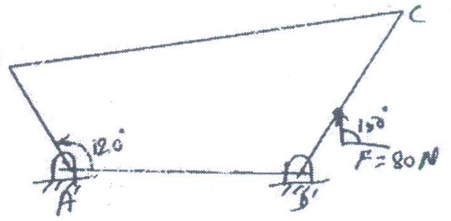

Fig. Q7(b)

OR

2 a. State 'D' Alembert's principle. **(08 Marks)**

b. The crank and connecting rod of a vertical single cylinder gas engine running at 1800 rpm are 60mm and 240mm respectively. The diameter of the Piston is 80mm and the mass of the reciprocating is 1.2kg. At a point during the power stroke when the Piston has moved 20mm from the top dead centre position, the pressure on the Piston is 800 kN/m^2. Determine :

i) Net force on the piston
ii) Thrust in the connecting rod
iii) Thrust on the sides of cylinder wall
iv) Engine speed at which the above values are zero. **(08 Marks)**

Module-2

3 For masses m_1 = 100kg, m_2 = 175kg, m_3 = 200kg and m_4 = 125kg are fixed to the crank of 200mm radius and revolve in planes I^{st}, II^{nd}, III^{rd} respectively. The angular position of the planes II^{nd}, III^{rd} and and IV^{th} with respect to I^{st} plane are 75°, 135° and 240° take in the same sense. Distance of plane $II^{n.}$ III^{rd} and IV^{th} from I^{st} are 600mm, 1800mm and 2400mm. Determine the magnitude and position of the balancing masses at the radius 600mm in planes L and M located in the middle of I^{st} and II^{nd} and in the middle of III^{rd} and IV^{th} respectively. **(16 Marks)**

OR

4 The piston of a 4 cylinder vertical inline engine reach their upper most position at 90° interval in order of their axial position, pitch of the cylinder = 0.35m ; length of the connecting rod = 0.42m. the engine runs at 600 rpm. If the reciprocating parts of each engine has a mass of 2.5kg. Find the unbalanced primary and secondary forces and couples. Take central plane of engine as reference plane. **(16 Marks)**

2

Module-3

5 a. Derive an expression for gyroscopic couple. **(06 Marks)**

b. A porter governor has equal arms each 250mm long and pivoted on the axis of rotation. Each ball has a mass of 5kg and the mass of the central load on the sleeve is 25kg. The radius of rotation of the ball is 150mm when the governor begins to lift and 200mm when the governor is at maximum speed. Find the minimum and maximum speeds and range of speed of the governor. **(10 Marks)**

OR

6 a. Define: i) Sensitiveness ii) Isochronism. **(04 Marks)**

b. A turbine rotor of a ship has a mass of 2.2 and Tonnes and rotates at 1800rpm clockwise when viewed from the stern. The radius of gyration of the rotor is 320mm. Determine the gyroscopic couple and its effect when the

i) Ship turns right at a radius of 250m with a speed of 25km/hr.

ii) Ship pitches with bow rising at on angular velocity of 0.8 rad/sec.

iii) Ship rolls at on angular velocity of 0.1 rad/sec. **(12 Marks)**

Module-4

7 a. Briefly explain, Free, Forced, damped and undamped vibration. **(08 Marks)**

b. Split up the harmonic motion X = 6 Cos (wt + 45°) into two harmonic motions. One of them having phase angle of zero degree and other having phase angle of 60°. Check solution by graphically. **(08 Marks)**

OR

8 a. Obtain the equivalent stiffness of spring when springs are connected in series and parallel. **(08 Marks)**

b. Obtain the natural frequency of the system shown in Fig Q8 (b). **(08 Marks)**

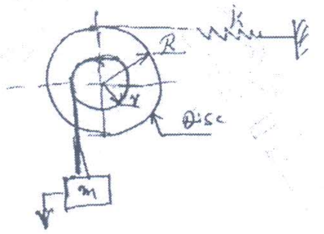

Fig. Q8(b)

Module-5

9 a. Define logarithmic decrement and derive the equation for same. **(08 Marks)**

b. Vibration system consisting of a mass 3kg a springs of stiffness 100kN/m and damper. Damping coefficient 30Ns/m. Determine Damping factor, critical damping coefficient logarithmic decrements, Ratio of two consecutive amplitudes.
Number of cycles after which the initial amplitude is reduced to 20%? **(08 Marks)**

OR

10 a. Derive an expression for magnification factor or amplitude ratio for spring mass system with viscous damping subjected to harmonic force. **(08 Marks)**

b. A vibratery body of mass 150kg supported on springs of total striffness 1050kN/m has a rotating unbalance force fo 525N at a speed of 6000rpm. If the damping factor is 0.3. Determine :

i) The amplitude caused by the unbalance and its phase angle

ii) The transmissibility

iii) The actual force transmitted and its phase angle. **(08 Marks)**

K S INSTITUTE OF TECHNOLOGY

USN | | | | | | | | | | | **10ME54**

Fifth Semester B.E. Degree Examination, Dec.2017/Jan.2018

Dynamics of Machines

Time: 3 hrs.   Max. Marks:100

Note: *Answer FIVE full questions, selecting at least TWO questions from each part.*

PART – A

1 a. Explain principle of virtual work with an example. **(04 Marks)**

b. In the following Fig. Q1 (b) a 4-bar mechanism is shown. Calculate the required value of T_2 and various forces on links for the equilibrium of the system. **(16 Marks)**

AB = 50 mm, BC = 66 mm, CD = 55 mm, CE = 25 mm, CF = 30 mm, BAD = 60° and AD = 100 mm

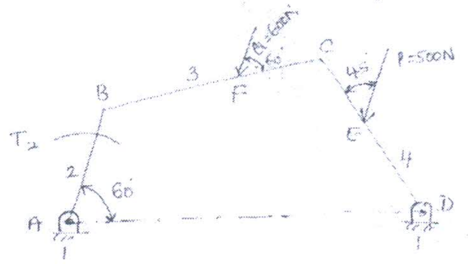

Fig. Q1 (b)

2 a. Explain the function of flywheel and show how its size and mass may be calculated by the aid of turning moment diagram. **(06 Marks)**

b. A punching press is required to punch 40 mm diameter holes in a plate of 15 mm thickness at the rate of 30 holes per minute. It requires 6 N-m of energy per mm^2 of sheared area. If the punching takes $\frac{1}{10}$ of a second and the rpm of the flywheel varies from 160 to 140. Determine the mass of the flywheel having radius of gyration of 1 metre. **(14 Marks)**

3 a. Derive an expression for frictional torque in a conical pivot bearing. Assume uniform pressure across the bearing surface. **(06 Marks)**

b. A belt drive is required to transmit 10 kW from a motor running at 600 rpm. The belt is 12 mm thick and has a mass density of 0.001 gm/mm^3. Safe stress in the belt is not to exceed 2.5 N/mm^2. Diameter of the driving pulley is 250 mm whereas the speed of the driven pulley is 220 rpm the two shafts are 1.25 m apart. The coefficient of friction is 0.25. Determine the width of the belt. **(14 Marks)**

4 a. Explain the procedure for balancing several masses rotating in the same plane by analytical method. **(04 Marks)**

b. A shaft carries four masses A, B, C and D of magnitude 200 kg, 300 kg, 400 kg and 200 kg respectively and revolving at radii 80 mm, 70 mm, 60 mm and 80 mm in planes measured from A at 300 mm, 400 mm and 700 mm. The angles between the cranks measured anticlockwise are A to B 45°, B to C 70°C and C to D 120°. The balancing masses are to be placed in planes X and Y. The distance between the planes A and X is 100 mm, between X and Y is 400 mm and between Y and D is 200 mm. If the balancing masses revolve at a radius of 100 mm. Find their magnitudes and angular positions. **(16 Marks)**

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

PART – B

5 a. What are in-line engines and state how they are balanced? **(06 Marks)**

b. A four cylinder vertical engine has cranks 150 mm long. The planes of rotation of the first, second and fourth cranks are 400 mm, 200 mm and 200 mm respectively from the third crank and their reciprocating masses are 50 kg, 60 kg and 50 kg respectively. Find the mass of the reciprocating parts for the third cylinder and relative angular positions of the cranks in order that the engine may be in complete primary balance. **(14 Marks)**

6 a. Define height of the governor and derive an expression for the height of the Hartwell governor. **(06 Marks)**

b. The arms of a porter governor are 300 mm long. The upper arms are pivoted on the axis of rotation. The lower arms are attached to a sleeve at a distance of 400 mm from the axis of rotation the mass of the load on the sleeve in 70 kg and the mass of each ball is 10 kg. Determine the equilibrium speed when the radius of rotation of the balls is 200 mm. If the friction is equivalent to a load of 20 N at the sleeve. What will be the range of speed for this position? **(14 Marks)**

7 a. Explain the effect of Gyroscopic couple on Navalship when it is steering and pitching. **(06 Marks)**

b. Each wheel of a four wheeled, rear engine automobile has a moment of inertia of 2.4 kgm^2 and an effective diameter of 660 mm. The rotating parts of the engine have a moment of inertia of 1.2 kgm^2. The gear ratio of engine of the back wheel is 3 to 1. The engine axis is parallel to the rear axle and the crankshaft rotates in the same sense as the road wheels. The mass of the vehicle is 2200 kg and the centre of the mass is 550 mm above the road level. The tack width of the vehicle is 1.5 m. Determine the limiting speed of the vehicle around a curve with 80 m radius so that all the four wheels maintain contact with the road surface. **(14 Marks)**

8 The following particulars relate to symmetrical circular cam operating a flat faced follower least radius = 16 mm, nose radius = 3.2 mm, distance between cam shaft centre and nose centre = 25 mm, angle of action of cam = 150°, and cam shaft speed = 600 rpm. Assuming that there is no dwell between ascent and descent. Determine the lift of the value, the flank radius and acceleration and retardation of the follower at the beginning of lift and apex of the nose. **(20 Marks)**

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USN ☐☐☐☐☐☐☐☐☐☐ **10ME/AU54**

Fifth Semester B.E. Degree Examination, June/July 2017

Dynamics of Machines

Time: 3 hrs. Max. Marks:100

Note: *Answer FIVE full questions, selecting at least TWO questions from each part.*

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg. 42+8 = 50, will be treated as malpractice.

PART – A

1 A slider crank mechanism has crank = 0.5m, connecting rod = 1.75m. When the crank is 60° away from IDC, a force of 1kN acts on slider, along line of stroke, away from crank centre. Find the torque T, needs to be applied on crank for static equilibrium of m/sm by

a. Virtual work method **(10 Marks)**

b. Drawing free body diagrams and applying equilibrium conditions. **(10 Marks)**

2 a. Explain in brief either "D'Alembert's principle" or "dynamically Equivalent system. **(06 Marks)**

b. Turning moment curve for one revolution of a multi cylinder engine above and below the line of mean resisting torque are given by −0.5, +1.2, −0.95, +1.45, −0.85, +0.71, −1.06 Sq. Cm. The vertical and horizontal scales are 1cm = 7000 N-m and 1cm = 30°. The engine speed is 800 rpm and it is desired that the fluctuation from minimum to maximum speed should not be more than 2% of average speed. Determine the moment of inertia of the flywheel. **(14 Marks)**

3 a. What are Pivot and Collar bearings? Explain in brief with sketches. **(06 Marks)**

b. An open belt connects two flat pulleys. The smaller pulley is 30cm in diameter and runs at 200rpm. The angle of lap on this pulley is 160° and the coefficient of friction between the belt and pulley face is 0.25. The belt is on the point of slipping when 2.61kW power is being transmitted. Which of the following alternative would be more effective in increasing the power transmitting capability?

i) Increasing the tension in the belt by 10%
ii) Increasing the coefficient of friction by 10% by the application of a suitable dressing to the belt. **(14 Marks)**

4 a. The weights W_1, W_2, W_3 and W_4 are 1962 N, 2943N, 2354N and 2550.6N respectively, in a plane perpendicular to shaft axis. The corresponding eccentricities are 20cm, 15cm, 25cm and 30cm respectively and the angles between the successive masses are 45°, 75° and 135°. Are these weights statically balanced? **(06 Marks)**

b. A shaft is supported in bearings 180cm apart and project 45cm beyond bearing at each end. The shaft carries three pulleys one at each end and one at the middle of its is length. The end pulleys weigh 471 N and 196.2N and their eccentricities are 1.5cm and 1.25cm respectively. The central pulley weighs 549.4N and its centre of gravity is 1.5cm from shaft axis. If the pulleys are arranged to give static balance, determine :

i) Relative angular positions of the pulleys and
ii) Dynamic forces at bearings when the shaft rotates at 300 rpm. **(14 Marks)**

PART – B

5 a. Explain Method of Direct and Reverse Crank'. **(06 Marks)**

b. The firing order in a 6 – cylinder vertical 4 – stroke in – line engine is 1-4-2-6-3-5. The stroke is 100mm and length of each connecting rod is 200mm. The pitch distances are 100mm, 100mm, 150mm, 100mm and 100mm respectively. The reciprocating mass per cylinder is 1kg and engine runs at 3000rpm. Determine maximum magnitudes of secondary unbalance force and couple, choosing a plane midway between the cylinders 3 and 4 as the reference plane. **(14 Marks)**

6 a. Explain in brief 'the effect of friction at sleeve on the performance of Porter Governor'. **(06 Marks)**

b. A spring loaded governor of the Hartnell type has arms of equal lengths. The weights rotate in a circle of 13cm diameter when the sleeve is in the mid-position and the weight arms are vertical. The equilibrium speed for this position is 450rpm, neglecting friction. The maximum sleeve movement is to be 2.5cm and the maximum variation of speed, taking friction into account is to be ± 5% of mid-position equilibrium speed. The weight of sleeve is 39N and the friction may be considered equivalent to 29N at the sleeve. The power of the governor must be sufficient to overcome the friction by a 1% change of speed either way at mid position. Determine, neglecting obliquity effect,

- i) Weight of each rotating mass
- ii) Spring stiffness in N/m
- iii) Initial compression of spring **(14 Marks)**

7 a. Explain in brief:

- i) Angular momentum
- ii) Spin motion
- iii) Processional motion. **(06 Marks)**

b. A rail Car has a total weight of 39240 N. there are two axles, each of which together with wheels has moment of inertia of 30 kg-m^2. The centre distance between the two wheels on an axle is 1.5m and each wheel is of 37.5cm radius. Each axle is driven by a motor and its speed is 3 times the speed of wheel. Each motor has a moment of inertia of 15 kg-m^2 and runs opposite to that of axle. The centre of gravity is 105cm above rails. Determine the limiting speed when it is negotiating a curve of 240m radius such that no wheel leaves the rail. **(14 Marks)**

8 a. Write a brief note on 'Undercutting in Cams'. **(06 Marks)**

b. A symmetrical Cam with convex flanks operates a flat footed follower. The lift is 8mm, base circle radius is 25mm and the nose radius is 12mm. If the total angle of cam action is 120°, find the radius of convex flanks. Also determine the maximum velocity and maximum acceleration when the cam shaft rotates at 500 rpm. **(14 Marks)**

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CRASH COURSE

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10ME54

Fifth Semester B.E. Degree Examination, May 2017

Dynamics of Machines

Time: 3 hrs. Max. Marks:100

Note: *Answer any FIVE full questions, selecting atleast TWO questions from each part.*

PART – A

1 a. State the conditions for a member to be in equilibrium
   i) When two forces act
   ii) When three forces act
   iii) When two forces and a torque act. **(06 Marks)**

b. For the four bar mechanism shown in Fig.Q1(b), find the required value of T_2 and various pin forces on the links for the equilibrium of the system. **(10 Marks)**

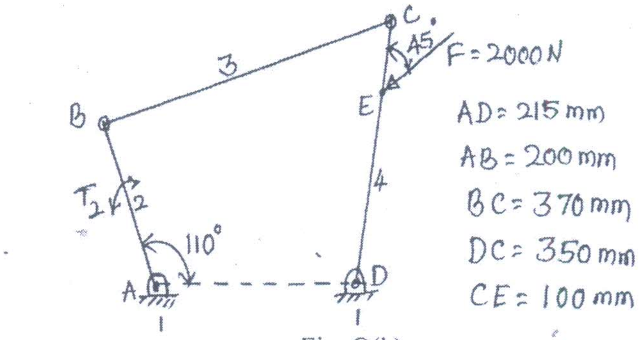

Fig. Q(b)

c. What is "principle of virtual work"? Explain. **(04 Marks)**

2 a. Explain D'Alemberts principle and state its significance. **(05 Marks)**

b. In a single–acting four–stroke engine, the work done by the gases during the expansion stroke is three times the work-done during the compression stroke. The work done during the suction and exhaust strokes is negligible. The engine develops 14 kW at 280 rpm. The fluctuation of speed is limited to 1.5% of the mean speed on either side. The turning – moment diagram during the compression and the expansion strokes may be assumed to be triangular in shape. Determine the inertia of the flywheel. **(15 Marks)**

3 a. Derive an expression for frictional torque in a flat pivot bearing. Assume uniform pressure across the bearing surface. **(06 Marks)**

b. A belt drive is required to transmit 10 kW from a motor running at 600 rpm. The belt is 12 mm thick and has a mass density of 0.001 gm/mm^3. Safe stress in the belt is not to exceed 2.5 N/mm^2. Diameter of the driving pulley is 250 mm whereas the speed of the driven pulley is 220 rpm. Two shafts are 1.25m apart. The coefficient of friction is 0.25. Determine the width of the belt. **(14 Marks)**

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

4 a. Explain static and dynamic balance of a system of revolving masses. **(06 Marks)**

b. A 3.6m long shaft carries 3 pulleys, two at its two ends and 3rd pulley at the midpoint. The two end pulleys have masses 79 and 40 kg respectively and their CG are 3 mm and 5 mm from the axis of shaft respectively. The middle pulley has a mass of 50 kg and its CG is 8 mm. The pulleys are so keyed to the shaft that the assembly is in static balance. The shaft rotates at 300 rpm in two bearings, 2.4m apart, with equal overhangs on either side find :

i) Relative angular position of the pulleys

ii) Dynamic reaction on the two bearings. **(14 Marks)**

PART – B

5 a. Prove that the resultant unbalanced force is minimum when half of the reciprocating masses are balanced by rotating masses i.e., when $C = \frac{1}{2}$. **(06 Marks)**

b. In a four cylinder engine the two outer cranks are 120° to each other and their reciprocating mass are each 100 kg. The distance between the planes of rotation of adjacent cranks are 450 mm, 750 mm and 450 mm. Length of each crank is 300 mm and length of each connecting rod is 1200 mm. Speed of engine is 240 rpm. Find :

i) The reciprocating masses and relative angular positions for each of the inner cranks

ii) The unbalanced secondary forces and couples if any, measured about the central plane for this arrangement arrived at for primary balancing. **(14 Marks)**

6 a. Establish a relationship between speed and height of porter governor, taking friction on the sleeve into account. **(08 Marks)**

b. A porter governor has equal arms each 250 mm long and pivoted on the axis of rotation. Each ball has a mass of 5 kg and the mass of the central load on the sleeve is 25 kg. The radius of rotation of the ball is 150mm when the governor begins to lift and 200 mm when the governor is at maximum speed. Find the range of speed, sleeve lift, governor effort and power of the governor in the following cases :

i) When the friction at the sleeve is neglected

ii) When the friction at the sleeve is equivalent to 10 N. **(12 Marks)**

7 a. With neat sketches, explain the effect of gyroscopic couple on pitching, steering and rolling of a ship. **(06 Marks)**

b. Each wheel of a four wheel, rear engine automobile has a moment of inertia of 2.4 kg-m^2 and an effective diameter of 660 mm. The rotating parts of the engine have moment of inertia of 1.2 kg-m^2. The gear ratio of engine to back axle is 3 : 1. The engine axis is parallel to rear axle and the crank shaft rotates in the same sense as the road wheel. The mass of the ventricle is 2200 kg and the centre of mass is 550 mm above the road level. The track width of the vehicle is 1.5m. Find the limiting speed of the vehicle around a curve with 80 m radius so that all the four wheels maintain contract with the road surface. **(14 Marks)**

8 For a symmetrical tangent cam operating a roller follower, the least radius of cam is 30 mm and roller radius is 15mm. The angle of ascent is 60°, the total lift is 15mm and the speed of the cam shaft is 300 rpm. Calculate :

i) Principal dimension of cam [i.e., the distance between the cam centre and nose centre, nose radius and angle of contact of cam with straight flank]

ii) Acceleration of the follower at the beginning of the lift, where the roller just touches the nose [i.e., flank merges into the nose] and at the apex of the circular nose. Assume that there is no dwell between ascent and descent. **(20 Marks)**

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K S INSTITUTE OF TECHNOLOGY

USN 1SB14ME057

10ME54

Fifth Semester B.E. Degree Examination, Dec.2016/Jan.2017

Dynamics of Machines

Time: 3 hrs. Max. Marks:100

Note: ***Answer FIVE full questions, selecting at least TWO questions from each part.***

PART – A

1 a. State the condition for static equilibrium of a body subjected to a system of, (i) two forces (ii) three forces (iii) member with two forces and a torque. **(06 Marks)**

b. For the mechanism shown in Fig. Q1 (b), find the required input torque for the static equilibrium. The lengths OA = 250 mm and AB = 650 mm, F = 500 N. **(14 Marks)**

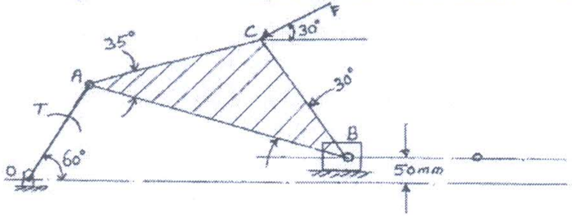

Fig. Q1 (b)

2 a. State and explain D'Alembert's principle. **(05 Marks)**

b. The turning moment diagram of a multicylinder engine has been drawn to a scale of 1 mm = 500 Nm torque and 1 mm to 6° of crank displacement. The intercepted areas between output torque curve and mean resistance line, taken in order from one end, in square millimeter area : -30, +410, -280, +320, -330, +250, -360, +280 and -260. If the mean speed is 800 rpm and fluctuation of speed is not to exceed 2% of mean speed, determine

(i) Mass of the flywheel

(ii) Mean diameter of the flywheel, if the centrifugal stress in the flkywheel rim is limited to 8 N/mm^2.

(iii) Dimensions of the rectangular cross section of the rim by taking the width of the rim as 5 times the thickness. The density of cast iron is 7200 kg/mm^3. **(15 Marks)**

3 a. Derive an expression for friction torque in case of flat collar with uniform pressure theory. **(05 Marks)**

b. An open belt transmits 15 kW power at a belt speed of 900 m/min. The belt embraces 4/9 circumference of the pulley. The thickness of belt is 10 mm. The coefficient of friction between belt and pulley surface is 0.3. Safe working stress in the material is 1.5 MPa. Density of the belt material is 1000 kg/m^3. Determine the width of the belt. **(15 Marks)**

4 a. What do you mean by static and dynamic balancing? **(05 Marks)**

b. A shaft carries four masses in parallel planes A, B, C, D in this order along its length. The masses at B and C are 18 kg and 12.5 kg respectively and each has an eccentricity of 60 mm. The masses at A and D have an eccentricity of 80 mm. The angle between the masses at B and C is 100° and that between masses at B and A is 190°, both being measured in the same direction. The axial distance between the planes A and B is 100 mm and that between B and C is 200 mm. If the shaft is in complete dynamic balance, determine (i) The magnitude of the masses at A and D (ii) The distance between planes A and D. (iii) The angular position of the mass at D. **(15 Marks)**

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

PART – B

5 a. Explain why only partial balancing is possible in reciprocating masses. **(05 Marks)**

b. A four crank engine has the two outer cranks set at 120° to each other, and their reciprocating masses are each 400 kg. The distance between the planes of rotation of adjacent cranks are 450 mm, 750 mm and 600 mm. If the engine is to be in complete primary balance, find the reciprocating mass and the relative angular position for each of the inner cranks.

If the length of each crank is 300 mm the length of each connecting rod is 1.2 m and the speed of rotation is 240 rpm. What is the maximum secondary unbalanced force? **(15 Marks)**

6 a. Define the following with respect to the working of governors : (i) Sensitiveness (ii) Isochronism (iii) Effort of a governor (iv) Stability of a governor. **(08 Marks)**

b. The arms of a porter governor are each 300 mm long and are hinged on the axis of rotation. The mass of each ball is 5 kg and mass of the sleeve is 15 kg. The radius of rotation of the ball is 200 mm, when the governor begins to lift and 250 mm, when the governor is at the maximum speed. Determine (i) Range of speed neglecting the sleeve friction. (ii) Range of speed, if the frictional force at the sleeve is 30 N. **(12 Marks)**

7 a. With neat sketches, explain the effect of gyroscopic couple on steering, pitching and rolling of a ship. **(08 Marks)**

b. An aeroplane flying at 240 km/h turns towards the left and completes a quarter circle of 60 m radius. The mass of the rotary engine and the propeller of the plane is 450 kg with a radius of gyration of 320 mm. The engine speed is 2000 rpm clockwise when viewed from the rear. Determine the gyroscopic couple on the aircraft and its effect.

In what way is the effect changed when the,

(i) Aeroplane turns towards right.

(ii) Engine rotates clockwise when viewed from the front (nose end) and the aeroplane turns left and right? **(12 Marks)**

8 The following data relate to a circular cam operating a flat faced follower:

Least diameter = 40 mm, Lift = 12 mm, Angle of action = 160°, Speed = 500 rpm. If the period of acceleration of the follower is 60° of the retardation during the lift, determine

(i) Principle dimensions of CAM.

(ii) Acceleration of the main points.

What is the maximum acceleration and deacceleration during the lift? **(20 Marks)**

* * * * *

B.Tech/2016/ME/ES/1/4

NATIONAL INSTITUTE OF TECHNOLOGY

ARUNACHAL PRADESH, YUPIA, Pin-791112
(Established by MHRD, Govt. of India)
END SEMESTER EXAMINATION (Jan-June), 2016

COURSE TITLE: Dynamics of Machinery
COURSE CODE: ME 601
MAX MARKS: 100
TIME: 3Hours

SET-I

Instructions:

1. Answer as many questions as you can from **each unit separately**.
2. The question paper consists of 4 groups of 35 marks each, out of which the maximum score will be limited to 25 marks only.
3. Figures in the margin indicate full marks.

UNIT: I

1. What is meant by reactive gyroscopic couple?
2. Define co-efficient of fluctuation of energy. [2]
3. Define crank effort and crank- pin effort. [3]
4. List the effects of partial balancing of locomotives. [4]
5. Derive an expression for the natural frequency of free transverse [3] and longitudinal vibrations by equilibrium method. [8]
6. A shaft 50 mm diameter and 3 metres long is simply supported at the ends and carries three loads of 1000 N, 1500 N and 750 N at 1 m, 2 m and 2.5 m from the left support. The Young's modulus for shaft material is 200 GN/m2. Find the frequency of transverse vibration. [8]
7. What will be the effect of the gyroscopic couple on a disc fixed at a certain angle to a rotating shaft? [7]

UNIT: II

1. The turbine.rotor of a ship has a mass of 3500 kg. It has a radius of gyration of 0.45 m and a speed of 3000 r.p.m. clockwise when looking from stern. Determine the gyroscopic couple and its effect upon the ship:
   a) When the ship is steering to the left on a curve of 100 m radius at a speed of 36 km/h.

b) When the ship is pitching in a simple harmonic motion, the bow falling with its maximum velocity. The period of pitching is 40 seconds and the total angular displacement between the two extreme positions of pitching is 12 degrees. [12]

2. The turning moment diagram for a petrol engine is drawn to the following scales: Turning moment, 1 mm^2 = 5 N-m ; crank angle, 1 mm = 1°. The turning moment diagram repeats itself at every half-revolution of the engine and the areas above and below the mean turning moment line taken in order are 295, 685, 40, 340, 960, 270 mm2. The rotating parts are equivalent to a mass of 36 kg at a radius of gyration of 150 mm. Determine the coefficient of fluctuation of speed when the engine runs at 1800 r.p.m. [11]

3. The measurements on a mechanical vibrating system show that it has a mass of 8 kg and that the springs can be combined to give an equivalent spring of stiffness 5.4 N/mm. If the vibrating system have a dashpot attached which exerts a force of 40 N when the mass has a velocity of 1 m/s, find:

a) critical damping coefficient,

b) damping factor,

c) logarithmic decrement, and

d) ratio of two consecutive amplitudes. [12]

UNIT: III

1. Find the natural frequency of the system shown in fig.1 below. [5]

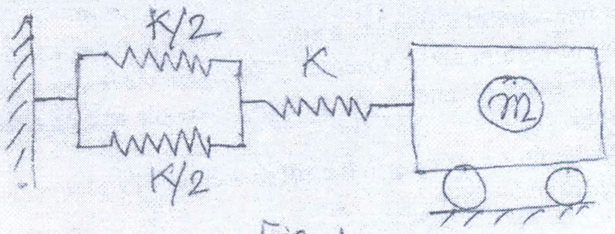

Fig.1.

2. Explain the terms 'under damping, critical damping' and 'over damping'. [5]
3. Calculate the whirling speed of a shaft 20 mm diameters and 0.6 m long carrying a mass of 1 kg at its mid-point. The density of the shaft material is 40 Mg/m^3, and Young's modulus is 200 GN/m^2. Assume the shaft to be freely supported. [8]
4. A rigid massless bar of length 'L' is hinged at its left end and carries a spring 'K_2' with mass 'M' at its right end. The bar is also supported by a spring 'K_1' at a distance 'a' from the left hinge. As shown in fig.2 Determine the natural frequency of the bar for angular oscillation 'θ'. [8]

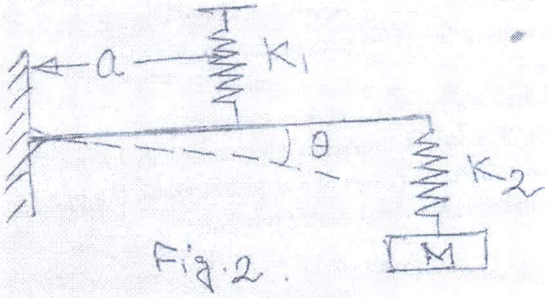

Fig.2.

5. What is the purpose of flywheel? How you differentiate the function of Governor in engine with flywheel? [4]
6. Deduce the mathematical expression of Swaying couple. [5]

UNIT: IV

1. Fig.3 Shows the arrangement of the cranks in a four crank symmetrical engine in which the masses of the reciprocating parts at cranks 1 and 4 are each equal to m_1 and at cranks 2 and 3 are each equal to m_2.

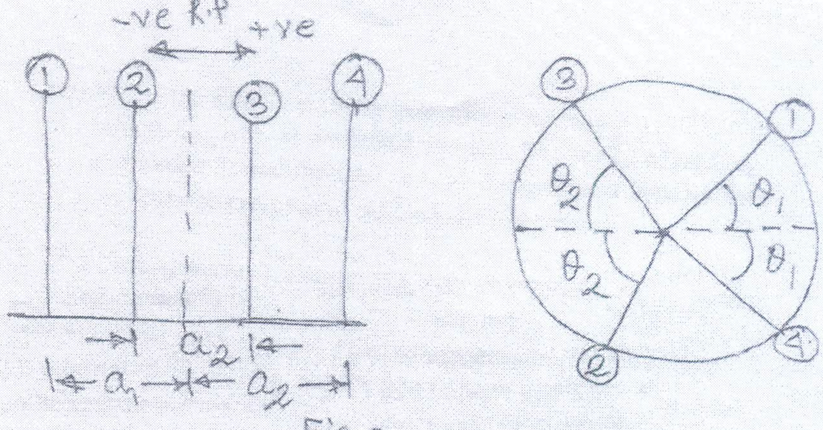

Fig.3

Show that the arrangement is balanced for primary forces and couples and for secondary forces provided that [15]

$$\frac{m_1}{m_2} = \frac{\cos\theta_1}{\cos\theta_2};\ \frac{a_1}{a_2} = \frac{\tan\theta_2}{\tan\theta_1};\ and\ \cos\theta_1 . \cos\theta_2 = \frac{1}{2}$$

2. Discuss the balancing of 4-stroke 4 cylinder engine. [8]
3. Define following terms: a) Hunting b) sensitiveness c) iso – chronisms. [6]
4. The crank and connecting rod of a steam engine are 0.3 m and 1.5 m in length. The crank rotates at 180 r.p.m. clockwise. Determine the velocity and acceleration of the piston when the crank is at 40 degrees from the inner dead centre position. [6]

B B6818 Pages: 4

Reg No.:_______________ Name:__________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION, APRIL 2018

Course Code: ME304

Course Name: DYNAMICS OF MACHINERY (ME, MP, AU, PE)

Max. Marks: 100 Duration: 3 Hours

PART A

Answer any three full questions, each carries 10 marks. Marks

1 The applied load on the piston of an offset slider-crank linkage shown in Fig.1 is 100 N, and the coefficient of friction between the slider and the guide is 0.27, using graphical method determine the magnitude and sense of torque τ_2 applied on OA for the static equilibrium of the linkage. (10)

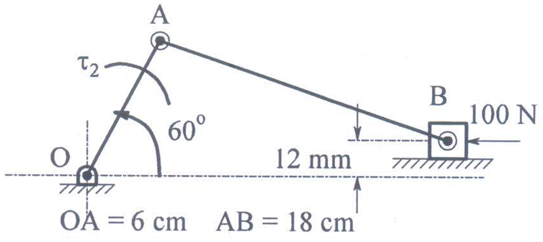

Fig. 1

2 Fig. 2 shows a four bar linkage on which various forces acting and their directions are shown. Determine the magnitude and direction of the torque applied on the link O_1A to keep the equilibrium of the linkage. Also determine the magnitude and direction of the forces transmitted to the frame of the linkage. Use Matrix method. (10)

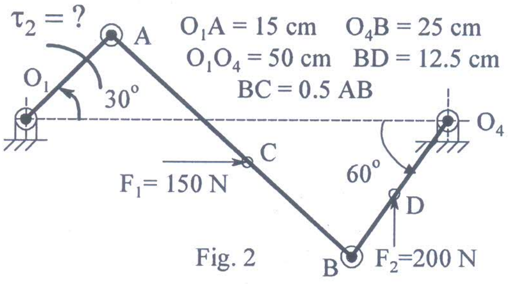

Fig. 2

3 Two 20^o straight bevel gears have a module pitch of 4mm, and 24 and 48 teeth respectively. The tooth face width is 50 mm. The pinion rotates at 1000 rpm and transmits 5 kW. The shafts are at 90^o. Determine the components of the gear force and show these on a sketch of the gears. (10)

4 In Fig. 3 a slider crank linkage is shown, in which various accelerations are shown (10)

and. The crank OA is running in the CCW direction. The mass of the connecting rod AB is 4 kg and moment of inertia about its mass centre G is 0.052 kg-m^2 and mass of the slider is 2.5 kg. Assume that the crank OA is weightless. Determine the magnitude and direction of the torque to be applied on the crank to balance the inertia effects of the linkage

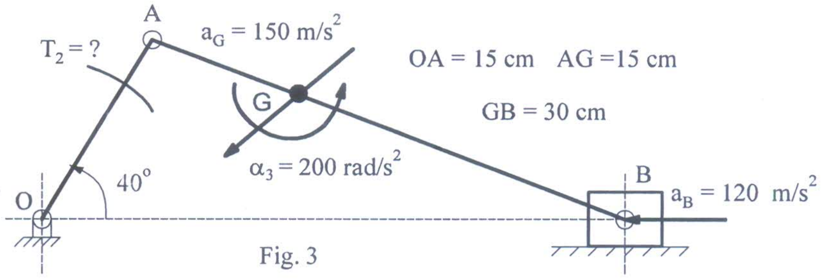

Fig. 3

PART B

Answer any three full questions, each carries 10 marks.

5 A constant torque 2.5 kW motor drives a riveting machine. The mass of the moving parts, including the flywheel is 125 kg at 70 cm radius. One riveting operation absorbs 10,000J of energy and takes 1.2 seconds. Speed of the flywheel is 240 rpm before riveting. Determine (1) No. rivets closed per hour and (2) the reduction in speed after the riveting operation. (10)

6 A shaft carries four rotating masses A of 5 kg, B of m_B *kg*, C of 4.5 kg, and D of 3.5 kg in this order from left to right. The effective radius of rotation of these masses from the left are respectively 30 cm, 40 cm, 35 cm and 25 cm. The plane of rotation of A and B are 35 cm apart and that between Band C are 45 cm apart. The angle between the A and C is 120°. (10)

Determine (i) the angle between A and B and that between A and D.

(ii) Distance between the planes of revolution of C and D,

(iii) the mass m_B, so that the system is incomplete balance

7 The turbine rotor of a ship weighs 550 kN and has a radius of gyration of 0.45m rotating at 2500 rpm in a CW direction when viewed from the aft. Ship pitches through a total angle of 12°. Assuming that the motion is being simple harmonic with a period of 15 second, determine (1) the maximum gyroscopic couple on the holding down bolts of the turbine and using the vector diagram, find the direction of yaw when the bow rises. (10)

8 Each road wheel of a motor cycle is of 60 cm diameter and has a moment of inertia of 1.2 kg-m^2. The motor cycle and the rider together weighs 250 kg and the combined centre of gravity is 65 cm above the ground level when the motor cycle is (10)

upright. The moment of inertia of the rotating parts of the engine is 0.18 kg-m^2. The engine rotates 4.5 times the speed of the road wheel in the same sense. Find the angle of heel necessary when the motor cycle is taking a turn of 40 m radius at a speed of 70kmph

PART C

Answer any four full questions, each carries 10 marks.

9 a) By neglecting the mass of the slender uniform rod is shown in Fig. 4(a), determine the natural frequency of free vibration of the mass for small oscillations (5)

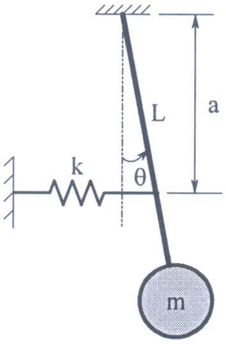

Fig. 4 (a) An oscillating pendulum

b) Find the frequency of the oscillations of the system shown in Fig. 4(b). The roller rolls on the surface without slipping. (5)

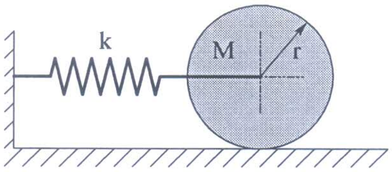

Fig. 4(b) A Cylinder rolling on a floor

10 A mass of 4.5 kg, hangs from a spring and makes damped vibration. The time of 50 complete oscillations is found to be 18 seconds and the ratio of first down ward displacement to the sixth is found to be 2.5. (10)

Find (i) the natural frequency of the system,

(ii) the stiffness of the spring in KN/m,

(iii) the damping coefficient in N-s/m,

(iv) the critical damping coefficient.

11 An electric motor weighing 100 kg is supported on isolators having a damping factor of 0.2. It runs at a speed of 1500 rpm and has a rotating unbalance of 10 kg-cm. What should be the stiffness of the isolators if the forces transmitted to the foundation is to be less than 10 % of the unbalanced force (10)

12 A rotor has a mass of 12 kg and mounted midway on a 24 mm diameter horizontal shaft supported at ends by bearings. The bearings are 1 m apart. The shaft rotates at (10)

2400 rpm. If the centre of mass of the rotor is 0.11 mm away from the geometric centre of the rotor due to certain manufacturing defects. Find the amplitude of steady state vibration. Take $E = 200GPa$

13 A centrifugal pump rotating at 400 rpm is driven by an electric motor at 1200 rpm through a single stage reduction gearing. The moment of inertia of the pump impeller and the motor are 150 kg-m^2 and 450 kg-m^2 respectively. The lengths of the pump shaft and the motor shaft are 500 mm and 200 mm and their diameters are 100 mm and 50 mm respectively. Neglecting the inertia of the gears, find the frequency of torsional oscillations of the system, and draw the mode shape. Take $G = 82$ GPa (10)

14 What do you understand by vibration pickups? With neat diagram explain the working of a seismometer. (10)

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Sample Hand written notes by faculty

MODULE 1: STATIC FORCE ANALYSIS:

Introduction:

The forces acting on the machine members may be because of many reasons like weight of components, forces of assembly, Externally applied loads, frictional forces, forces due to change in temp, Inertia forces & Spring forces. In Design of mechanisms, it is desired to know the magnitude & direction of these forces.

Thus the study of forces in machines involve two types.

(a) Static force analysis:

All the machines have mass & if parts of a machine are accelerating inertial forces will be associated with the motion, if the magnitude of these inertia forces produced due to acceleration of mass are small relative to Externally applied loads, then they can be neglected, such an analysis is referred to a Static force analysis.

(b) Dynamic force analysis:

Some times inertia forces are significant & are to be considered. An analysis that includes inertia effects is called as Dynamic force Analysis.

** **Bodies in Equillibrium | Reaction b/w members Disregarding friction**

State the condition of Equillibrium for a body subjected to two forces, three forces, four force & two force & a torque

1 Static Equillibrium :- {Dec 16/Jan-17; Dec-14/Jan 15; June/July-13; June/July-14, June/July-16; Dec-10; Dec-11; Dec-12; June-12; June-11;

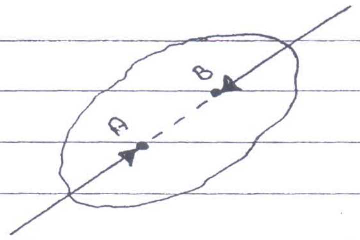
A rigid body is said to be in Static Equillibrium if it remains in it's state of rest (or) motion.

classmate

For a free body in Static Equillibrium Sum of all forces acting on the body must be zero & the Vector Sum of all moments about any chosen Point must also be zero.

i,e $\Sigma F = 0$
ΣC (or) $\Sigma M = 0$ } Eqn for Equillibrium.

(2) Equillibrium of two force System:-

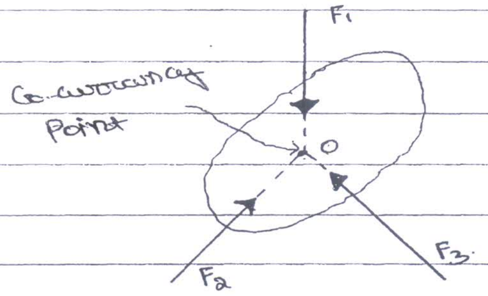


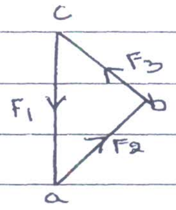
A member subjected to two forces will be in Equillibrium if

(a) The forces acts along the same line i,e forces are collinear.

(b) Two forces must be Equal in magnitude & opposite in direction.

(3) Equillibrium of Three force System:-





A body acted upon by a three forces will be in Equillibrium if & only if

(a) Resultant of all three forces is zero.

(b) The forces are con-current i,e Line of action of all three forces intersect at a point known as concurrency point.

Fig shows body acted by three forces F_1, F_2 & F_3 Line of action intersect at point 'o'. Since the force polygon is closed the resultant force is zero.

K. S. INSTITUTE OF TECHNOLOGY

#14, Raghuvanahalli, Kanakapura Main Road, Bengaluru-5600109

DEPARTMENT OF MECHANICAL ENGINEERING

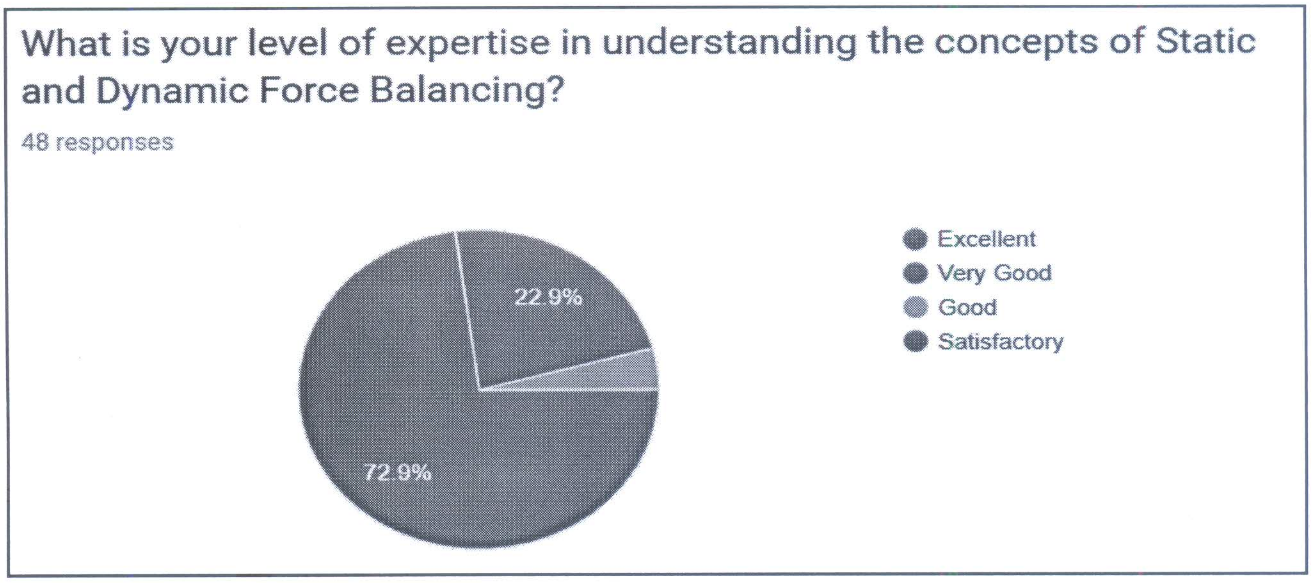
FACULTY NAME: ANILKUMAR A

SUBJECT: DYNAMICS OF MACHINERY

SUBJECT CODE: 15ME52

YEAR/SEM/SEC: III / V / 'B'

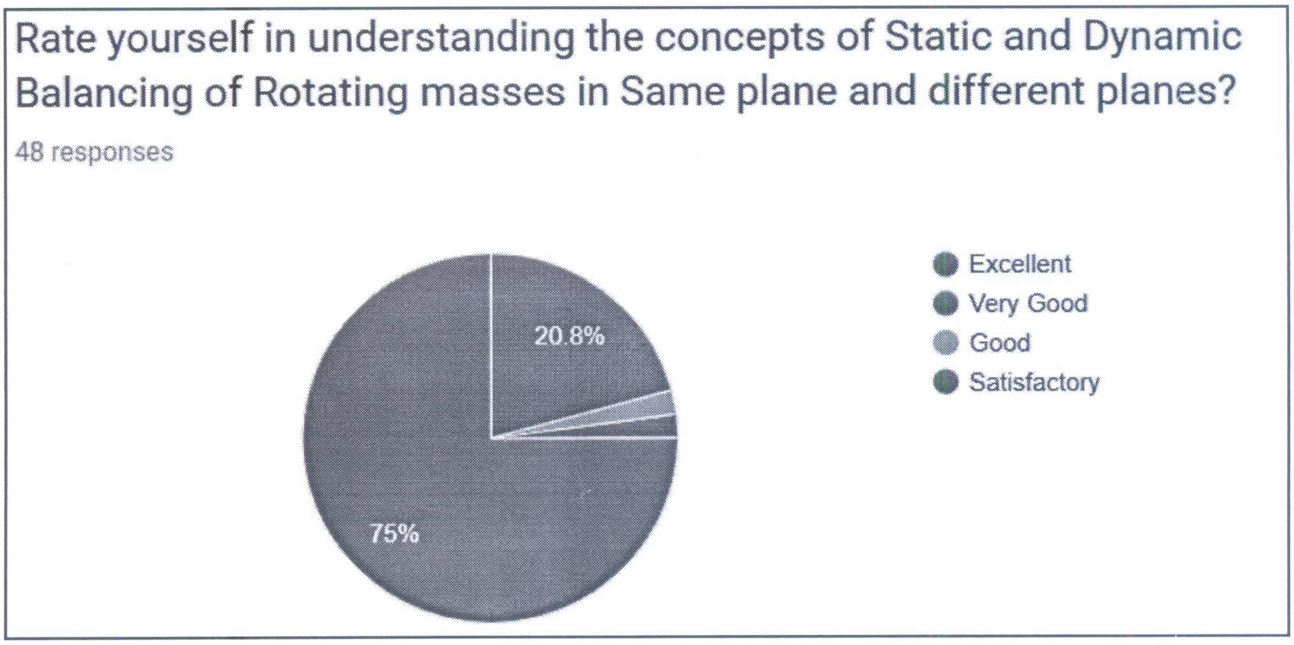
1.



What is your level of expertise in understanding the concepts of Static and Dynamic Force Balancing?

48 responses

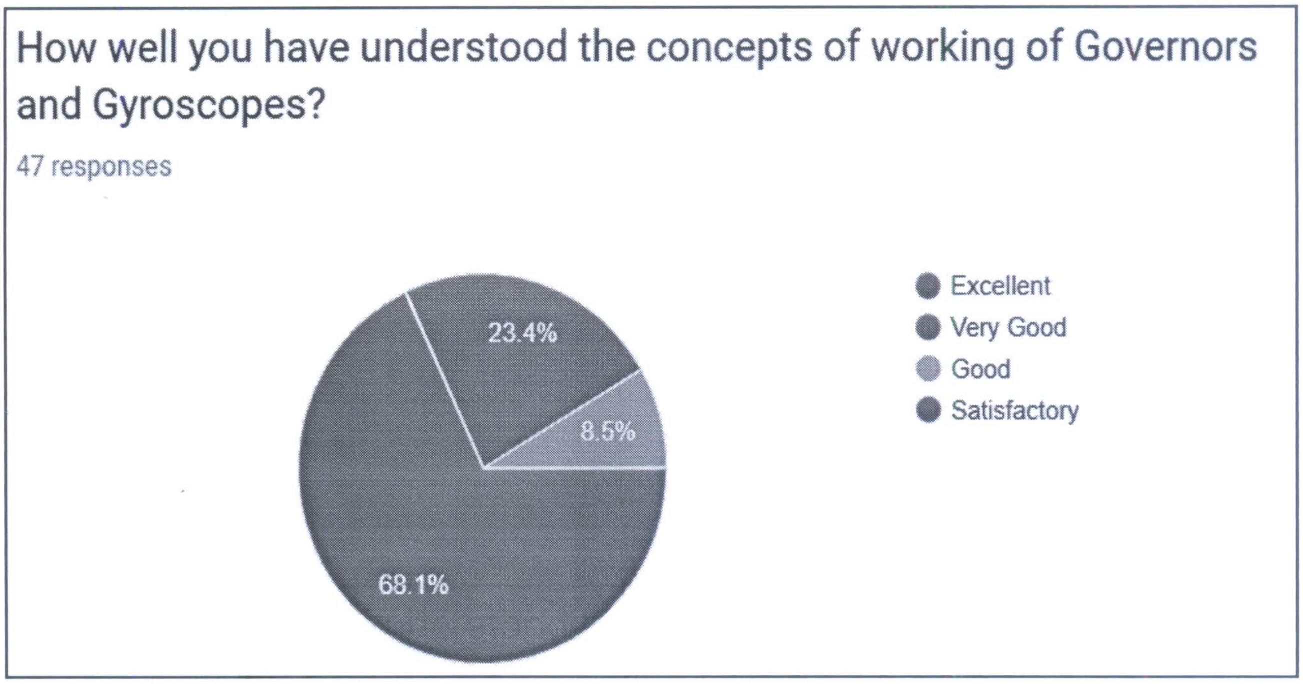
2.



Rate yourself in understanding the concepts of Static and Dynamic Balancing of Rotating masses in Same plane and different planes?

48 responses

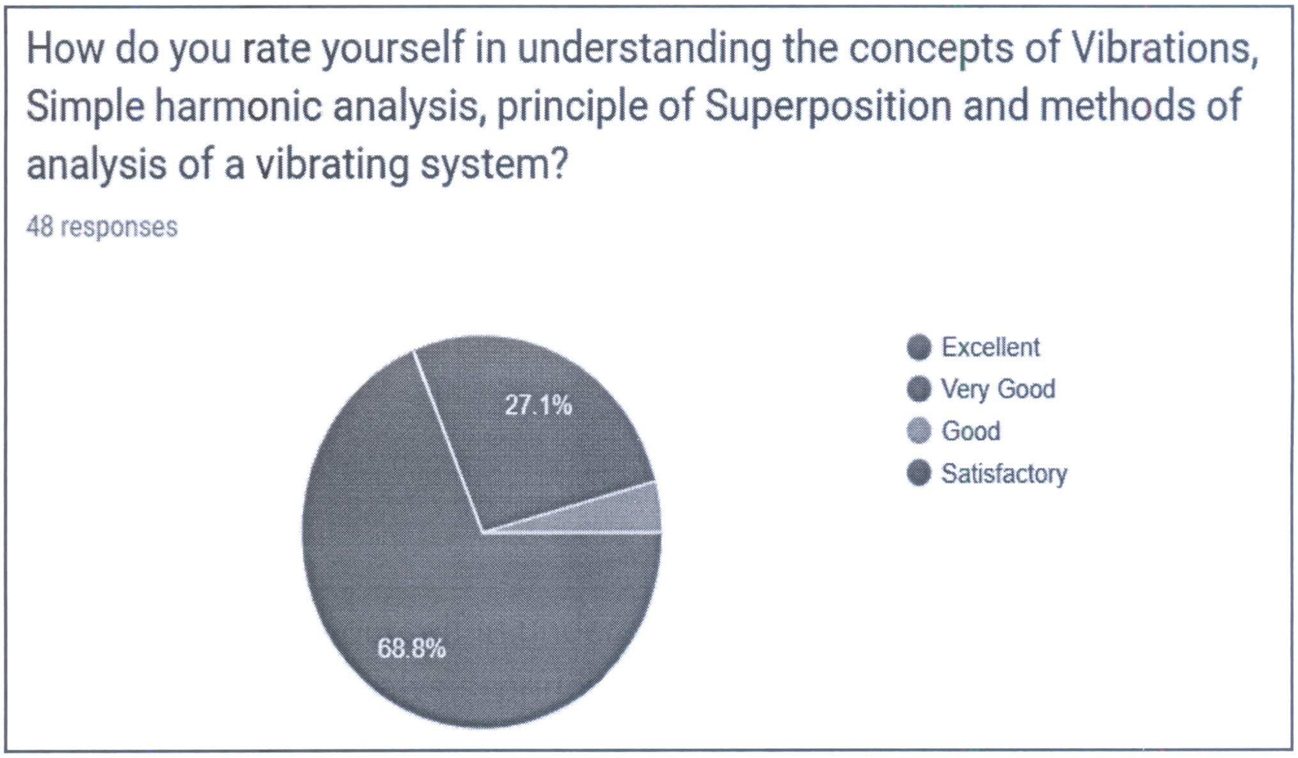
3.



How well you have understood the concepts of working of Governors and Gyroscopes?

47 responses

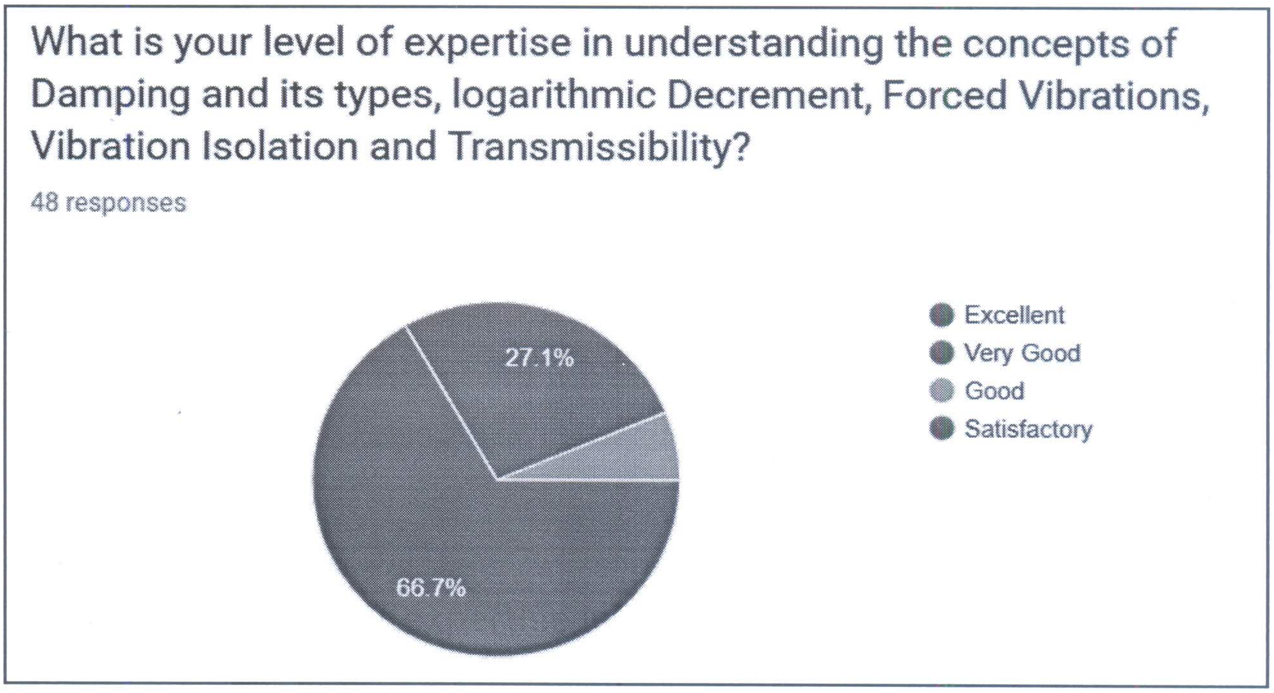
4.



How do you rate yourself in understanding the concepts of Vibrations, Simple harmonic analysis, principle of Superposition and methods of analysis of a vibrating system?

48 responses

5.



What is your level of expertise in understanding the concepts of Damping and its types, logarithmic Decrement, Forced Vibrations, Vibration Isolation and Transmissibility?

48 responses

K. Rama

K S INSTITUTE OF TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

YEAR / SEMESTER	III / V
COURSE TITLE	DYNAMICS OF MACHINERY
COURSE CODE	15ME52
ACADEMIC YEAR	2018-19

CO Attainment Level	Significance
Level 3	60% and above students should have scored >= 60% of Total marks
Level 2	55% to 59% of students should have scored >= 60% of Total marks
Level 1	50% to 54% of students should have scored >= 60% of Total marks

For Direct attainment , 50% of CIE and 50% of SEE marks are considered.

For indirect attainment, Course end survey is considered.

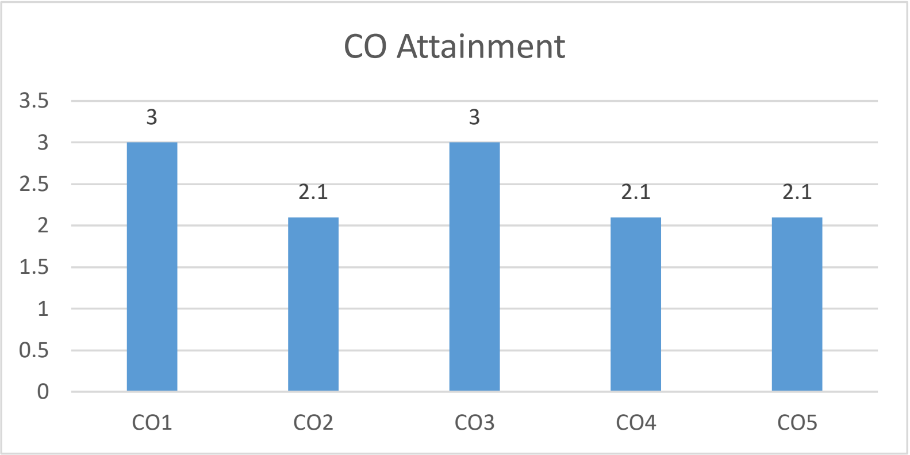
CO attainment is 90%of direct attainment + 10% of Indirect atttainment.

PO attainment = CO-PO mapping strength/3 * CO attainment .

Sl. No	USN	Name of the Student	15ME52																														
			IA1					A1					IA2					A2					IA3					A3					SEE
			CO1	CO2	CO3	CO4	CO5	CO1	CO2	CO3	CO4	CO5	CO1	CO2	CO3	CO4	CO5	CO1	CO2	CO3	CO4	CO5	CO1	CO2	CO3	CO4	CO5	CO1	CO2	CO3	CO4	CO5	
			44	19				10	5					19	38				**5**	**10**						44	16				10	10	**80**
1	1KS16ME002	ABHIJEETH.B.BHAT	41	17.5				10	5					17.5	33				5	10						0	0				10	10	41
2	1KS16ME004	ABHILASH.S	21	8				10	5					8	26				5	10						0	0				10	10	52
3	1KS16ME006	ABHISHEK PAREEK	31	10				10	5					10	26				5	10						0	0				10	10	60
4	1KS16ME007	ABHISHEK RAJ- Got Eligible_VP	31	16				10	5					16	24				5	10						44	16				10	10	34
5	1KS16ME008	AMOGHA.M.KEKUDA	19	14				10	5					14	25				5	10						0	0				10	10	71
6	1KS16ME009	ASHOK KUMAR KARMALI	42	18.5				10	5					18.5	38				5	10						0	0				10	10	55
7	1KS16ME010	ASHWIN MAIYA.M	38	17				10	5					17	32				5	10						0	0				10	10	61
8	1KS16ME011	BHARATHKUMAR.P	24	5				10	5					5	18				5	10						0	0				10	10	49
9	1KS16ME012	BHARGAV JOSHI	37	16				10	5					16	38				5	10						0	0				10	10	41
10	1KS16ME013	BHUVAN BHARADWAJ V K	18	7.5				10	5					7.5	0				5	10						38	9				10	10	35
11	1KS16ME014	CHANDAN KUMAR.N.P	28	5				10	5					5	11				5	10						27	3				10	10	54
12	1KS16ME015	CHIRAG.B.P	36	18				10	5					18	32				5	10						0	0				10	10	60
13	1KS16ME016	DEEPAK.R.GOWDA	13	5				10	5					5	12				5	10						44	10				10	10	53
14	1KS16ME019	HARISH HADIMANI	15	4.5				10	5					4.5	0				5	10						38	16				10	10	50
15	1KS16ME021	HARSHA.S	40	13				10	5					13	38				5	10						0	0				10	10	40
16	1KS16ME022	HARSHAVARDHAN.N	27	13				10	5					13	7				5	10						44	14				10	10	57
17	1KS16ME023	HARSHITH.S	17	8				10	5					8	27				5	10						44	16				10	10	36
18	1KS16ME024	HEMANTH.R	42	17				10	5					17	38				5	10						0	0				10	10	28
19	1KS16ME025	HEMANTH KUMAR.D.L	22	9.5				10	5					9.5	12				5	10						24	16				10	10	34
20	1KS16ME026	HITESH.C.S	24	12				10	5					12	25				5	10						38	16				10	10	43
21	1KS16ME027	IMRAN KHAN	41	12				10	5					12	23				5	10						0	0				10	10	54
22	1KS16ME028	IRANNA CHANABASAPPA TELI	25	8.5				10	5					8.5	19				5	10						0	0				10	10	32
23	1KS16ME029	JAGADISH.P.SHETTI	25	11				10	5					11	36				5	10						0	0				10	10	53
24	1KS16ME030	JAYANTH.P	35	18				10	5					18	31				5	10						0	0				10	10	55
25	1KS16ME031	JAYDEEP.B	5	1.5				10	5					1.5	0				5	10						44	16				10	10	40
26	1KS16ME032	JUNAID KHAN	32	11.5				10	5					11.5	25				5	10						0	0				10	10	48
27	1KS16ME033	KANISHKA.P.SHANKAR	26	8				10	5					8	14				5	10						44	5				10	10	45
28	1KS16ME035	KAUSHIK.K.H	12	14				10	5					14	25				5	10						15	3				10	10	46
29	1KS16ME036	KIRAN PRAKASH AKOLKAR	28	8.5				10	5					8.5	17				5	10						0	0				10	10	35
30	1KS16ME038	M.VENKATESH KASHYAP	8	9				10	5					9	18				5	10						35	10				10	10	56
31	1KS16ME040	MADAN.S	32	12				10	5					12	26				5	10						0	0				10	10	59
32	1KS16ME044	MANOJ.R	21	3				10	5					3	9				5	10						0	0				10	10	44
33	1KS16ME045	MOHAMMED YASIR RIAZ	28	3				10	5					3	24				5	10						0	0				10	10	64
34	1KS16ME046	MOHAN KUMAR.N	31	13.5				10	5					13.5	27				5	10						38	16				10	10	34
35	1KS16ME047	NAGARJUN.S	10	8.5				10	5					8.5	21				5	10						0	0				10	10	29
36	1KS16ME048	NAGARJUN.S	16	9.5				10	5					9.5	17				5	10						25	6				10	10	45
37	1KS16ME049	NAGESH.T.S	37	11				10	5					11	34				5	10						0	0				10	10	33
38	1KS16ME052	NAVEEN DESHPANDE	33	13				10	5					13	25				5	10						44	16				10	10	16
39	1KS16ME053	NITHIN.N	21	4				10	5					4	0				5	10						26	5				10	10	55
40	1KS16ME054	P.VIGNESH	23	3.5				10	5					3.5	31				5	10						0	3				10	10	62
41	1KS16ME055	PAPPU KUMAR SINGH	33	10				10	5					10	36				5	10						31	3				10	10	51
42	1KS16ME056	PAVAN KUMAR.L	25	2.5				10	5					2.5	28				5	10						0	0				10	10	45
43	1KS16ME058	PECHU MUTHU.S	26	5				10	5					5	30				5	10						0	0				10	10	55
44	1KS16ME060	PRAJWAL KRISHNA	36	14.5				10	5					14.5	38				5	10						0	0				10	10	25
45	1KS16ME061	PRAKASH RAJU.S	34	17				10	5					17	38				5	10						0	0				10	10	28
46	1KS16ME062	PRAMOD.R	14	4				10	5					4	3				5	10						30	3				10	10	41
47	1KS16ME063	PRAMOD RAJ.K	41	15				10	5					15	38				5	10						0	0				10	10	47
48	1KS16ME064	PRANAV.J.ATHREY	33	0				10	5					0	0				5	10						35	3				10	10	51
49	1KS16ME067	RAJKUMAR.S.K	0	7				10	5					7	13				5	10						27	16				10	10	35
50	1KS16ME069	RAMESH PAL.P	34	17				10	5					17	38				5	10						0	0				10	10	24
51	1KS16ME070	RISHI.R.NAIK	40	16				10	5					16	30				5	10						0	0				10	10	43
52	1KS16ME073	SAGAR.N	31	3.5				10	5					3.5	0				5	10						38	16				10	10	40

53	1KS16ME075	SHAIK MOINUDDIN	14	5.5				10	5					5.5	13				5	10						30	3				10	10	59
54	1KS16ME076	SHARATH.S.YADAV	14	5.5				10	5					5.5	31				5	10						0	0				10	10	36
55	1KS16ME057	PAVITHRA.B	32	15				10	5					15	32				5	10						0	0				10	10	53
56	1KS16ME081	SHIVARAJ.N.S	20	5.5				10	5					5.5	19				5	10						0	0				10	10	62
57	1KS16ME082	SHIVASHANKAR.B.M	24	5				10	5					5	34				5	10						0	0				10	10	56
58	1KS16ME083	SIRISH GOVARDHAN	39	16.5				10	5					16.5	22				5	10						30	12				10	10	50
59	1KS16ME084	SOWJANYA.D	30	5.5				10	5					5.5	0				5	10						0	0				10	10	62
60	1KS16ME085	SREEKARA.K.B	25	8				10	5					8	32				5	10						0	0				10	10	56
61	1KS16ME086	SUDARSHAN.T	40	15.5				10	5					15.5	22				5	10						35	13				10	10	51
62	1KS16ME087	SUDHARSHAN.M.D	24	14				10	5					14	15				5	10						40	12				10	10	54
63	1KS16ME089	SUMESH.R	23.5	11				10	5					11	21				5	10						0	0				10	10	57
64	1KS16ME090	SUPREETH.K.R	4	3.5				10	5					3.5	5				5	10						0	0				10	10	56
65	1KS16ME093	VARUN.C	33	17				10	5					17	24				5	10						0	0				10	10	56
66	1KS16ME094	VASANTH KUMAR.S	37	13.5				10	5					13.5	20				5	10						0	0				10	10	60
67	1KS16ME095	VIJAYA KUMAR.M.S	14	4				10	5					4	37				5	10						0	0				10	10	69
68	1KS16ME096	VIJAYKUMARNAIK.T.C	12	10.5				10	5					10.5	31				5	10						38	14				10	10	59
69	1KS16ME097	VINAY.B.V	18	11				10	5					11	28				5	10						30	14				10	10	57
70	1KS16ME098	VINAY.V.P	14	10				10	5					10	31				5	10						38	14				10	10	
71	1KS16ME099	VINITH.P	34	7				10	5					7	0				5	10						40	12				10	10	47
72	1KS16ME100	VITHAN.T.R	32	9.5				10	5					9.5	24				5	10						39	13				10	10	53
73	1KS17ME401	ARUNKUMAR.E	33	8				10	5					8	13				5	10						0	0				10	10	38
74	1KS17ME402	ARUN KUMAR.R	35	10				10	5					10	31				5	10						0	0				10	10	
75	1KS17ME404	CHETHAN.C.R	30	6				10	5					6	28				5	10						0	0				10	10	40
76	1KS17ME405	DARSHAN.H.R	30	10				10	5					10	24				5	10						20	8				10	10	50
77	1KS17ME406	DEEPAK.E	17	5				10	5					5	13				5	10						30	14				10	10	47
78	1KS17ME407	DEVIPRASAD.M	22	7.5				10	5					7.5	26				5	10						0	0				10	10	28
79	1KS17ME408	GUHAN BHASKAR	21	11.5				10	5					11.5	37				5	10						0	0				10	10	49
80	1KS17ME409	GURUPRASAD.T.M	14	6.5				10	5					6.5	7				5	10						4	4				10	10	40
81	1KS17ME410	GURUSWAMY.H	15	13				10	5					13	20				5	10						30	14				10	10	40
82	1KS17ME411	JEEVAN ABHISHEK	19	6				10	5					6	29				5	10						36	16				10	10	42
83	1KS17ME412	KANTHARAJU.K.N	18	6.5				10	5					6.5	17				5	10						7	5				10	10	43
84	1KS17ME413	KIRAN.S	16	3				10	5					3	0				5	10						0	0				10	10	39
85	1KS17ME415	LOHITH.R	12	10				10	5					10	20				5	10						0	0				10	10	52
86	1KS17ME416	MAHADEVA RAJU.H.E	23	12.5				10	5					12.5	15				5	10						30	10				10	10	31
87	1KS17ME417	MAHESH.D	39	14				10	5					14	17				5	10						36	16				10	10	37
88	1KS17ME418	MANISH.N.D	39	16.5				10	5					16.5	37				5	10						8	8				10	10	45
89	1KS17ME419	MITHUN.S	0	7.5				10	5					7.5	20				5	10						36	12				10	10	52
90	1KS17ME420	MOHAN KUMAR.C	9	4				10	5					4	9				5	10						0	0				10	10	60
91	1KS17ME421	MOHAN KUMAR.K	0	0				10	5					0	0				5	10						42	18				10	10	25
92	1KS17ME422	NAGESH.S	26	13.5				10	5					13.5	28				5	10						6	6				10	10	50
93	1KS17ME423	NIKHIL GOWDA.N.S	21	9				10	5					9	24				5	10						42	14				10	10	60
94	1KS17ME425	PRATAP.L	15	3.5				10	5					3.5	5				5	10						42	18				10	10	40
95	1KS17ME426	PRATHEEK.P	33	14.5				10	5					14.5	19				5	10						0	0				10	10	54
96	1KS17ME430	RAKESH.B.R	16	3				10	5					3	0				5	10						0	0				10	10	43
97	1KS17ME431	RAKSHITH.L	27	5.5				10	5					5.5	0				5	10						36	14				10	10	42
98	1KS17ME432	RAVI.K.R	29	15.5				10	5					15.5	30				5	10						36	12				10	10	37
99	1KS17ME434	SHASHANK.Y.K	26	15.5				10	5					15.5	27				5	10						35	13				10	10	36
100	1KS17ME435	SHASHIKUMAR.C.R	21	3				10	5					3	0				5	10						42	14				10	10	53
101	1KS17ME437	SRINIVASA.B.V	14	10.5				10	5					10.5	36				5	10						35	13				10	10	52
102	1KS17ME439	SURABHI.N	16	7.5				10	5					7.5	17				5	10						16	16				10	10	28
103	1KS17ME440	SUSHMA.Y.S	18	0				10	5					0	0				5	10						35	13				10	10	58
104	1KS17ME441	TEJAS.P.N	0	8.5				10	5					8.5	31				5	10						10	2				10	10	37
105	1KS17ME442	THRIVENI.M	15	7				10	5					7	6				5	10						0	0				10	10	54
106	1KS17ME444	VINAY.S	37	4.5				10	5					4.5	5				5	10						12	12				10	10	42
60% of Maximum marks (X)			26	11	00	00	00	06	03	00	00	00	00	11	23	00	00	00	03	06	00	00	00	00	00	26	10	00	00	00	06	06	48
No. of students above X			46	38	00	00	00	106	106	00	00	00	00	38	55	00	00	00	106	106	00	00	00	00	00	42	38	00	00	00	106	106	52
Total number of students (Y)			106	106	00	00	00	106	106	00	00	00	00	106	106	00	00	00	106	106	00	00	00	00	00	106	106	00	00	00	106	106	104
CO Percentage			43.40	35.85	#DIV/0!	#DIV/0!	#DIV/0!	100.00	100.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	35.85	51.89	#DIV/0!	#DIV/0!	#DIV/0!	100.00	100.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	39.62	35.85	#DIV/0!	#DIV/0!	#DIV/0!	100.00	100.00	50.00
			CO1	CO2	CO3	CO4	CO5	CO1	CO2	CO3	CO4	CO5	CO1	CO2	CO3	CO4	CO5	CO1	CO2	CO3	CO4	CO5	CO1	CO2	CO3	CO4	CO5	CO1	CO2	CO3	CO4	CO5	SEE
LEVEL			0	0	#DIV/0!	#DIV/0!	#DIV/0!	3	3	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0	1	#DIV/0!	#DIV/0!	#DIV/0!	3	3	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0	0	#DIV/0!	#DIV/0!	#DIV/0!	3	3	1

CO Attainment							
CO	**CIE**	**SEE**	**DIRECT ATTAINMENT**	**Level**	**COURSE EXIT SURVEY**	**LEVEL**	**ATTAINMENT**
CO1	**71.70**	**50.00**	**60.85**	**3.00**	**60.00**	**3.00**	**3**
CO2	**67.92**	**50.00**	**58.96**	**2.00**	**60.00**	**3.00**	**2.1**
CO3	**75.94**	**50.00**	**62.97**	**3.00**	**60.00**	**3.00**	**3**
CO4	**69.81**	**50.00**	**59.91**	**2.00**	**60.00**	**3.00**	**2.1**
CO5	**67.92**	**50.00**	**58.96**	**2.00**	**60.00**	**3.00**	**2.1**
AVERAGE							**2.46**



	IA1	A1	IA2	A2	IA3	A3	AVG
CO1	43.40	100.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	71.70
CO2	35.85	100.00	35.85	100.00	#DIV/0!	#DIV/0!	67.92
CO3	#DIV/0!	#DIV/0!	51.89	100.00	#DIV/0!	#DIV/0!	75.94
CO4	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	39.62	100.00	69.81
CO5	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	35.85	100.00	67.92

Co-Po Mapping Table														
CO'S	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PS01**	**PSO2**
CO1	3	2	2	_	_	_	_	_	_	_	_	_	3	2
CO2	3	2	2	_	_	_	_	_	_	_	_	_	3	2
CO3	2	2	1	_	_	_	_	_	_	_	_	_	3	1
CO4	3	2	1	_	_	_	_	_	_	_	_	_	3	1
CO5	3	2	1	_	_	_	_	_	_	_	_	_	3	1
AVG	2.80	2.00	1.40	_	_	_	_	_	_	_	_	_	3.00	1.40

PO ATTAINMENT TABLE																
CO'S	**CO Attainment in %**	**CO RESULT**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PS02**
CO1	3.00	Y	3.00	2.00	2.00	_	_	_	_	_	_	_	_	_	3.00	2.00
CO2	2.10	Y	2.10	1.40	1.40	_	_	_	_	_	_	_	_	_	2.10	1.40
CO3	3.00	Y	2.00	2.00	1.00	_	_	_	_	_	_	_	_	_	3.00	1.00
CO4	2.10	Y	2.10	1.40	0.70	_	_	_	_	_	_	_	_	_	2.10	0.70
CO5	2.10	Y	2.10	1.40	0.70	_	_	_	_	_	_	_	_	_	2.10	0.70
Average			2.26	1.64	1.16	_	_	_	_	_	_	_	_	_	2.46	1.16