Roll No.

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST 1

Sem & AY: Odd Sem 2019-20
Course Code: MEC 214
Course Name: DYNAMICS OF MACHINES
Program & Sem: B.Tech & V

Date: 28.09.2019
Time: 9.30AM to 10.30AM
Max Marks: 40
Weightage: 20%

Instructions:

(i) *Use graph sheet to draw toque – moment (T-Θ) diagram*

Part A [Memory recall Questions]

Answer all the Questions. Each Question carries two marks. (4Qx2M=8M)

1. State the conditions for static equilibrium of a two force and a toque member. (CO.NO.1) [Knowledge]
2. State and explain D Alembert's principle. (CO.NO 1) [Knowledge]
3. Derive an expression for maximum fluctuation of energy in a flywheel. (CO.NO.2) [Knowledge]
4. Draw a sketch of engine mechanism (slider crank mechanism) and show the various forces acting on the engine components. (CO.NO.1) [Knowledge]

Part B [Thought Provoking Questions]

Answer all Questions. Each Question carries four marks. (3Qx4M=12M)

5. Draw T-Θ diagram for three cylinder double acting steam engine and show that it requires a lighter flywheel compared to single cylinder double acting steam engine. (CO.NO.2) [Comprehension]
6. Explain, how flywheel helps to meet uneven torque requirement in punching press application. (CO.NO.2) [Comprehension]

7. Prove that, the piston executes a simple harmonic motion when the connecting rod is large. (CO.NO.1) [Comprehension]

Part C [Problem Solving Questions]

Answer both the Questions. Each question carries ten marks. **(2Qx10M=20M)**

8. A four bar mechanism as shown in figure 1 with the following dimensions, is acted upon by a force as shown in the figure. AD=500 mm, AB=400 mm, BC=1000 mm, DC=750 mm, DE=350 mm. Determine the input torque on the link AB for static equilibrium of the mechanism.

(CO.NO.1) [Comprehension]

Figure 1

9. In a machine, the intermittent operations demand the torque to be applied as follows.
   a) During the first half revolution, the torque increases from 800 N-m to 3000 N-m.
   b) During the next one revolution, the torque remains constant.
   c) During the next one revolution, the torque decreases uniformly from 3000 N-m to 800 N-m.
   d) During last half revolution, the torque remains constant.

   Thus, a cycle is completed in 4 revolutions. The motor to which the machine is coupled exerts a constant toque at a mean speed of 250 rpm. A flywheel of mass 1800 kg and radius of gyration 500 mm is fitted to the shaft. Determine:

   i. Power of the motor
   ii. Total fluctuation of speed of the machine shaft. (CO.NO.2) [Application]

SCHOOL OF ENGINEERING

Semester: V

Course Code: MEC 214

Course Name: Dynamics of Machines

Date: 28 Sep 2019

Time: 9.30 am to 10.30 am

Max Marks: 40

Weightage: 20%

Extract of question distribution [outcome wise & level wise]

Q.NO	C.O.NO	Module Number/ Module Title	Memory recall type [Marks allotted] Bloom's Level		Thought provoking type [Marks allotted] Bloom's Level		Problem Solving type [Marks allotted] Bloom's Level		Total Marks
1.	1	Module I Force Analysis	2M	K					2
2.	1	Module I Force Analysis	2M	K					2
3.	2	Module 2 Flywheel	2M	K					2
4.	1	Module I Force Analysis	2M	K					2
5.	2	Module 2 Flywheel			4M	C			4
6.	2	Module 2 Flywheel			4M	C			4
7.	1	Module I Force Analysis			4M	C			4
8.	1	Module I Force Analysis					10M	C	10
9.	2	Module 2 Flywheel					10M	A	10
	Total Marks		08		12		20		40

K =Knowledge Level   C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.
[I hereby certify that All the questions are set as per the above guide lines. Dr Mahesha K]

Reviewers' Comments

Annexure- II: Format of Answer Scheme

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

SCHOOL OF ENGINEERING

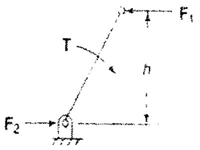
SOLUTION

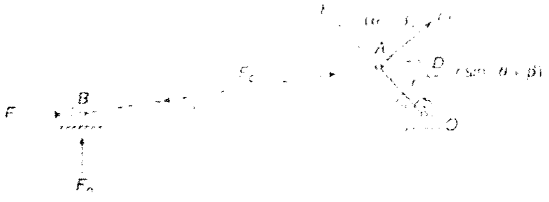
Semester: V
Course Code: MEC 214
Course Name: Dynamics of Marines
Branch & Sem: MEC / V

Date: 28 Sep 2019
Time: 9.30 am to 10.30 am
Max Marks: 40
Weightage: 20%

Part A

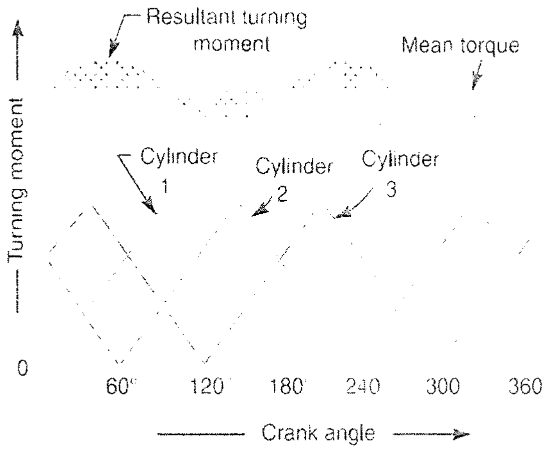
(4Q x 2M = 12 Marks)

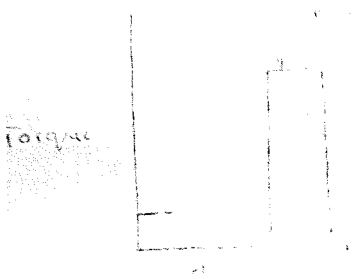
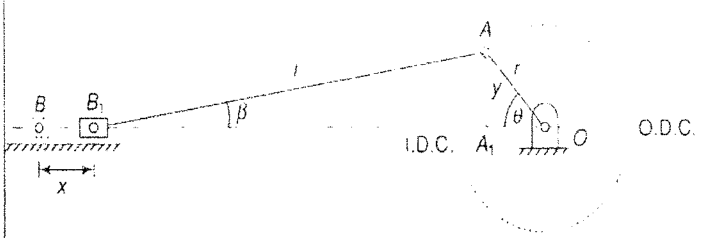
Q No	Solution	Scheme of Marking	Max. Time required for each Question
1.	 $T = F_1 \times h = F_2 \times h$ A member under the action of two forces and an applied torque will be in equilibrium if ○ The forces are equal in magnitude, parallel in direction and opposite in sense ○ The forces form a couple which is equal and opposite to the applied torque.	1M 1M	3 Min
2.	"The inertia forces and couples, and the external forces and torques on a body together give an equilibrium" $\Sigma F + F_i = 0$ where ΣF = Sum of external forces. F_i=Inertia Force $\Sigma T + C_i = 0$ where	1M 0.5M	3 Min

	ΣT – Sum of external Torques. C_I – Inertia Couple	0.5M	
3.	Maximum fluctuation of energy $\Delta E = \text{Maximum K.E.} - \text{Minimum K.E.}$ $= \frac{1}{2} \times I(\omega_1)^2 - \frac{1}{2} \times I(\omega_2)^2 = \frac{1}{2} \times I\left[(\omega_1)^2 - (\omega_2)^2\right]$ $= \frac{1}{2} \times I(\omega_1 + \omega_2)(\omega_1 - \omega_2) = I.\omega(\omega_1 - \omega_2)$ $\Delta E = I.\omega^2\left(\frac{\omega_1 - \omega_2}{\omega}\right)$ $= I.\omega^2.C_S = m.k^2.\omega^2.C_S$	**1M** **1M**	3 Min
4.	 $F_T = F_Q \sin(\theta+\beta)$ $= \frac{F_P}{\cos\beta}\sin(\theta+\beta)$ $F_P = F_L \pm m_R.g - F_I - R_F$ $F_Q = \frac{F_P}{\cos\beta}$ $F_N = F_Q\sin\beta = F_P\tan\beta$ $F_R = F_Q\cos(\theta+\beta) = \frac{F_P}{\cos\beta}\cos(\theta+\beta)$	**0.5 M x Any four**	3 Min

Part B

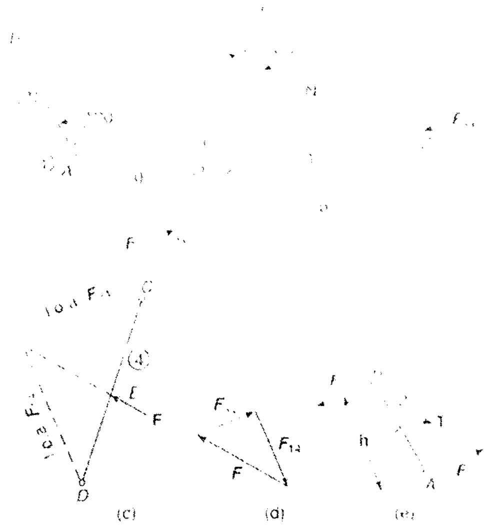
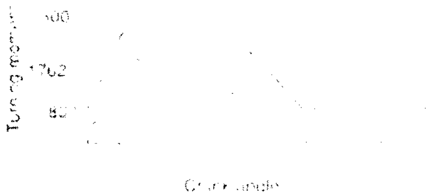
(3Q x 4M = 12 Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
5.		T-Θ diagram – 3M Resultant and mean torque – 1M	6 Min

	 	T-Θ diagram 2M Explanation – 2M	6 Min
7.	 $x = B_1B = BO - B_1O$ $= BO - (B_1A_1 + A_1O)$ $= (l + r) - (l\cos\beta + r\cos\theta)$ $= (nr + r) - (nr\cos\beta + r\cos\theta)$ $= r[(n + 1) - (n\cos\beta + \cos\theta)]$ $\cos\beta = \sqrt{1 - \sin^2\beta}$ $= \sqrt{1 - \frac{y^2}{l^2}}$ $= \sqrt{1 - \frac{(r\sin\theta)^2}{l^2}}$ $= \sqrt{1 - \frac{\sin^2\theta}{n^2}}$ $= \frac{1}{n}\sqrt{n^2 - \sin^2\theta}$ $x = r[(n + 1) - (\sqrt{n^2 - \sin^2\theta} + \cos\theta)]$ $= r[(1 - \cos\theta) + (n - \sqrt{n^2 - \sin^2\theta})]$ If the connecting rod is very large as compared to the crank, n^2 will be large, Then $x = r(1 - \cos\theta)$ This is the expression for a simple harmonic motion.	Derivation 3M 1M	6 Min

Part C (2Q x 10M = 20 Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question

8.	 $F_{34} = 47.8$ N Now, $F_{34} = F_{43} = F_{23} = F_{32}$ Member 2 will be in equilibrium if F_{12} is equal, parallel and opposite to F_{32} and $T = -F_{32} \times h = -47.8 \times 393 = -18\ 780$ N.mm The input torque has to be equal and opposite to this couple i.e., $T = 18.78$ N m (clockwise)	FBD 4 M Force Polygon 2M 1M 3M	15 Min
9.	 Torque for one complete cycle, T = area $OABCDEF$ or T = Area $OAEF$ + Area ABE + Area $EBCM$ + Area MCD $= 8\pi \times 800 + \frac{\pi \times 2200}{2} + 2\pi \times 2200 + \frac{2\pi \times 2200}{2}$ $= 14\ 100\pi$ N m $T_m = \frac{14\ 100\pi}{8\pi} = 1762.5$ N m $P = T_m\omega = 1762.5 \times \frac{2\pi \times 250}{60} = 46\ 143$ W or 46.143 kW (ii) $IG = JI \times \frac{BG}{BI} = \pi \times \frac{3000 - 1762.5}{3000 - 800}$ $= 1.767$ $HK = MD \times \frac{CH}{CM} = 2\pi \times \frac{3000 - 1762.5}{3000 - 800}$ $= 3.534$ The fluctuation of energy is equal to the area above the mean torque line Δe = Area $IBCK$ = area IBG + area $GBCH$ + area HCK	T-Θ Diagram 2M WD / Cycle 2M Tm – 1M P – 1M Δ E- 2M Cs- 2M	15 Min

	$(3000 - 1562.5)\frac{1.26}{2} \times 2\pi \times \frac{3.84}{2}$ $= 11\,055$ N m $K = \frac{E}{mk^2\omega^2}$ $= \frac{11\,055}{1800 \times (0.8)^2 \times \left(\frac{2\pi \times 380}{60}\right)^2}$ $= 0.0358$ or 3.58%		

Roll No.													

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST – 2

Sem & AY: Odd Sem 2019-20
Course Code: MEC 214
Course Name: DYNAMICS OF MACHINES
Program & Sem: B.Tech, (MECH) & V Sem

Date: 20.11.2019
Time: 09:30 AM to 10:30 AM
Max Marks: 40
Weightage: 20%

Instructions:
- *(i)* *Read the question properly and answer accordingly.*
- *(ii)* *Question paper consists of 3 parts.*
- *(iii)* *Scientific and Non-programmable calculators are permitted.*

Part A [Memory Recall Questions]

Answer both the questions. Each question carries five marks. (2Qx5M=10M)

1. With a neat sketch, discuss the gyroscopic effect on an aero plane when the rotating masses of engine rotate in a clockwise direction when viewed from the tail and it takes a left turn. (C.O.NO.3)[Comprehension]
2. Four masses m_1, m_2, m_3 and m_4 are 200 kg, 300 kg, 240 kg and 260 kg respectively. The corresponding radii of rotation are 0.2 m, 0.15 m, 0.25 m and 0.3 m respectively and the angles between successive masses are 45°, 75° and 135°. Find the position and magnitude of the balance mass required, if its radius of rotation is 0.2 m. (C.O.NO.4)[Comprehension]

Part B [Thought Provoking Questions]

Answer both the questions. Each question carries eight marks. (2Qx8M=16M)

3. The turbine rotor of a ship has a mass of 8 tonnes and a radius of gyration 0.6 m. It rotates at 1800 r.p.m. clockwise, when looking from the stern. Determine the gyroscopic couple, if the ship travels at 100 km/hr and steer to the left in a curve of 75 m radius. (C.O.NO.3)[Application]

4. A uniform disc of 150 mm diameter has a mass of 5 kg. It is mounted centrally in bearings which maintain its axle in a horizontal plane. The disc spins about it axle with a constant speed of 1000 r.p.m. while the axle precesses uniformly about the vertical at 60 r.p.m. The directions of rotation are as shown in Fig. 1. If the distance between the bearings is 100 mm, find the resultant reaction at each bearing due to the mass and gyroscopic effects. (C.O.NO.3)[Application]

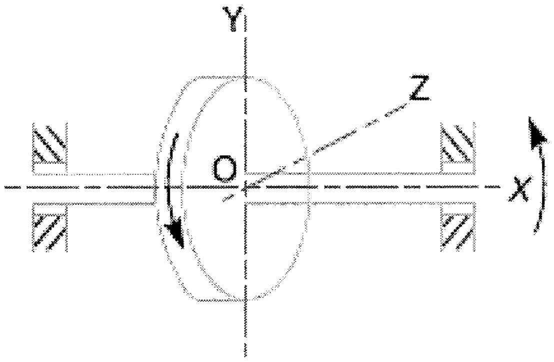


Fig 1.

Part C [Problem Solving Questions]

Answer the Question. The question carry fourteen marks. (1Qx14M=14M)

5. A, B, C and D are four masses carried by a rotating shaft at radii 100 mm, 125 mm, 200 mm 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 relative angular settings of the four masses so that the shaft shall be in complete balance. (C.O.NO.4)[Application]

SCHOOL OF ENGINEERING

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

Semester: 5th Sem

Course Code: MEC 214

Course Name: Dynamics of Machines

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels			Thought provoking type [Marks allotted] Bloom's Levels			Problem Solving type [Marks allotted]			Total Marks
			K			C			A			
1	3	3						5				5
2	4	4						5				5
3	3	3									8	8
4	3	3									8	8
5	4	4									14	14
	Total Marks							10			30	40

K =Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

Annexure- II: Format of Answer Scheme

SCHOOL OF ENGINEERING

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

SOLUTION

Date: 20-11-2019

Semester: 5th Sem

Time: 09:30 am to 10:30 am

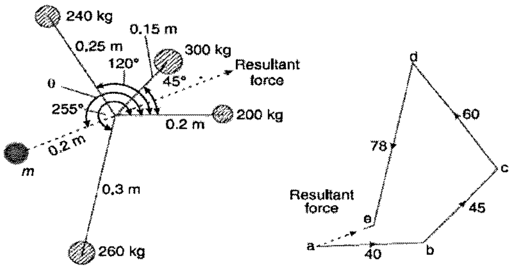
Course Code: MEC 214

Max Marks: 40

Course Name: Dynamics of Machines

Weightage: 20%

Part A (2Q x 5M = 10 Marks)

Q N o	Solution	Scheme of Marking	Max. Time required for each Question
1	If the plane takes a left turn, the angular momentum vector is shifted and may be represented by the vector ob. The change is shown by the vector ab and is the active gyroscopic couple. This vector is in the horizontal plane and is perpendicular to the vector oa in the limit. The reactive vector is given by b'a' which is equal and opposite to the vector ab. The interpretation of this vector shows that the couple acts in the vertical plane and is counter-clockwise when viewed from the right-hand side of the plane. This indicates that it tends to raise the nose and depress the tail of the aeroplane.	**5 marks**	**5 min**
2	2. *Graphical method* The magnitude and the position of the balancing mass may also be found graphically as discussed below : 1. First of all, draw the space diagram showing the positions of all the given masses as shown in Fig 21.6 (*a*). 2. Since the centrifugal force of each mass is proportional to the product of the mass and radius, therefore $m_1.r_1 = 200 \times 0.2 = 40$ kg-m $m_2.r_2 = 300 \times 0.15 = 45$ kg-m $m_3.r_3 = 240 \times 0.25 = 60$ kg-m $m_4.r_4 = 260 \times 0.3 = 78$ kg-m 3. Now draw the vector diagram with the above values, to some suitable scale, as shown in Fig. 21.6 (*b*). The closing side of the polygon *ae* represents the resultant force. By measurement, we find that *ae* = 23 kg-m.  (*a*) Space diagram. (*b*) Vector diagram	**Vector Dia: 3 marks** **Cal: 2 marks**	**5 min**

	4. The balancing force is equal to the resultant force, but *opposite* in direction as shown in Fig. 21.6 (*a*). Since the balancing force is proportional to $m.r$, therefore $m \times 0.2$ = vector ea = 23 kg-m or $m = 23/0.2 =$ **115 kg Ans.** By measurement we also find that the angle of inclination of the balancing mass (m) from the horizontal mass of 200 kg. θ = **201° Ans.**		

Part B

(2Q x 8M = 16 Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
3	Solution. Given: m = 8 t = 8000 kg ; k = 0.6 m ; N = 1800 r.p.m. or $\omega = 2\pi \times 1800/60$ = 188.5 rad/s ; v = 100 km/h = 27.8 m/s ; R = 75 m We know that mass moment of inertia of the rotor, $I = m.k^2 = 8000\ (0.6)^2 = 2880$ kg-m^2 and angular velocity of precession, $\omega_p = v / R = 27.8 / 75 = 0.37$ rad/s We know that gyroscopic couple, $C = I.\omega.\omega_p = 2880 \times 188.5 \times 0.37 = 200\ 866$ N-m = 200.866 kN-m Ans. We have discussed in Art. 14.6, that when the rotor rotates in clockwise direction when looking from the stern and the ship steers to the left, the effect of the reactive gyroscopic couple is to raise the bow and lower the stern. [redacted]	Cal: 5 marks Effect: 3 marks	10 mins
4	Solution. Given: d = 150 mm or r = 75 mm = 0.075 m ; m = 5 kg ; N = 1000 r.p.m. or $\omega = 2\pi \times 1000/60$ = 104.7 rad/s (anticlockwise); N_p = 60 r.p.m. or $\omega_p = 2\pi \times 60/60$ = 6.284 rad/s (anticlockwise); x = 100 mm = 0.1 m We know that mass moment of inertia of the disc, about an axis through its centre of gravity and perpendicular to the plane of disc, $I = m.r^2/2 = 5\ (0.075)^2/2 = 0.014$ kg m^2 ∴ Gyroscopic couple acting on the disc, $C = I.\ \omega.\ \omega_p = 0.014 \times 104.7 \times 6.284 = 9.2$ N-m The direction of the reactive gyroscopic couple is shown in Fig.14.4 (*b*). Let F be the force at each bearing due to the gyroscopic couple. ∴ $F = C/x = 9.2/0.1 = 92$ N The force F will act in opposite directions at the bearings as shown in Fig. 14.4 (*a*). Now let R_A and R_B be the reaction at the bearing A and B respectively due to the weight of the disc. Since the disc is mounted centrally in bearings, therefore, $R_A = R_B = 5/2 = 2.5$ kg $= 2.5 \times 9.81 = 24.5$ N	Torque Cal: 4 marks Reaction : 4 marks	10 mins

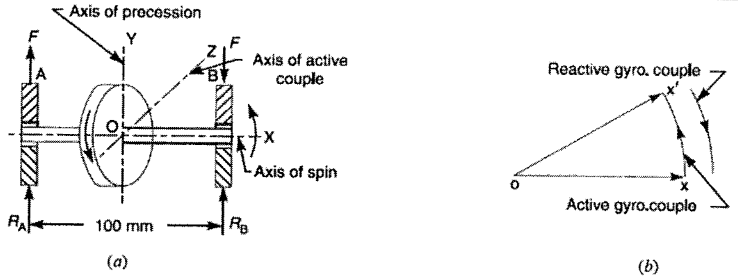


Fig. 14.4

Resultant reaction at each bearing

Let R_{A1} and R_{B1} = Resultant reaction at the bearings A and B respectively.

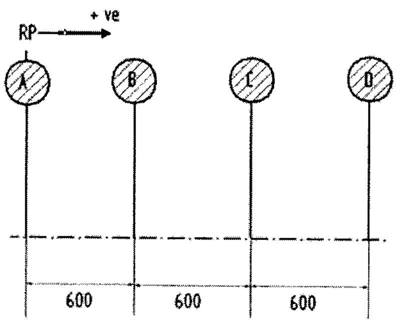
Since the reactive gyroscopic couple acts in clockwise direction when seen from the front, therefore its effect is to increase the reaction on the left hand side bearing (*i.e.* A) and to decrease the reaction on the right hand side bearing (*i.e.* B).

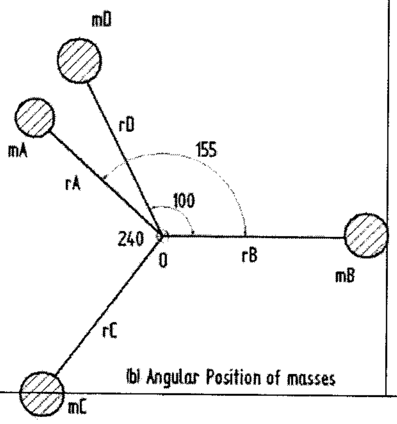
∴ $R_{A1} = F + R_A = 92 + 24.5 = 116.5$ N (upwards) Ans.

and $R_{B1} = F - R_B = 92 - 24.5 = 67.5$ N (downwards) Ans.

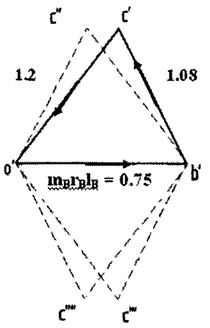
Part C

(1Q x 14M = 14 Marks)

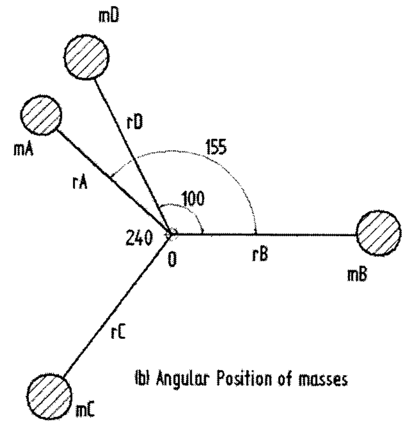
<table>
<tr><th>Q No</th><th>Solution</th><th>Scheme of Marking</th><th>Max. Time required for each Question</th></tr>
<tr><td>5</td><td>
<table>
<tr><th>Plane</th><th>Mass (m) kg</th><th>Radius (r) m</th><th>Centrifugal force/ω^2 (m r) kg-m</th><th>Distance from Ref. plane 'A' m</th><th>Couple/ω^2 (m r L) kg-m^2</th><th>Angle θ</th></tr>
<tr><td>A (R.P.)</td><td>m_A= ?</td><td>0.1</td><td>m_A = 0.1 r_A m_A</td><td>0</td><td>0</td><td>θ_A= ?</td></tr>
<tr><td>B</td><td>10</td><td>0.125</td><td>m_B r_B = 1.25</td><td>0.6</td><td>0.75</td><td>θ_B=0</td></tr>
<tr><td>C</td><td>5</td><td>0.2</td><td>m_C r_C = 1.0</td><td>1.2</td><td>1.2</td><td>θ_C=?</td></tr>
<tr><td>D</td><td>4</td><td>0.15</td><td>m_D r_D = 0.6</td><td>1.8</td><td>1.08</td><td>θ_D=?</td></tr>
</table>


(a) Position of planes of masses


(b) Angular Position of masses
</td><td>Table 3 marks
Diagram 3 marks
Cal: 4 marks
Answer 4 marks</td><td>15 min</td></tr>
</table>



(c) Couple polygon

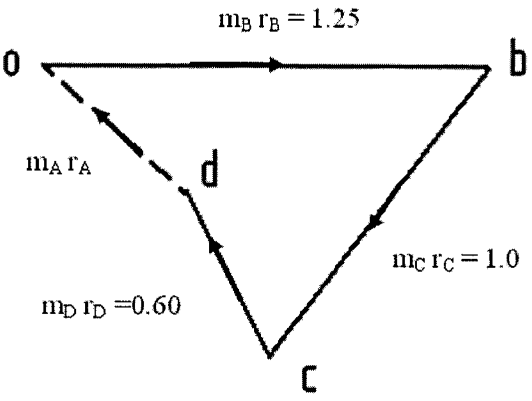


(b) Angular Position of masses

$$\theta_D = 100^0 \quad \text{and} \quad \theta_C = 240^0 \quad \text{Ans}$$

Step 4:

In order to find m_A and its angular setting draw the force polygon as shown in figure (d).



(d) Force polygon

Closing side of the force polygon od represents the product $m_A r_A$. i.e.

$$m_A r_A = 0.70 \text{kg-m}$$

Therefore, $m_A = \frac{0.70}{r_A}$ =7kg Ans

Step 5:

$$\theta_A = 155^0 \quad \text{Ans}$$

SCHOOL OF ENGINEERING

END TERM FINAL EXAMINATION

Semester: Odd Semester: 2019 - 20
Course Code: MEC 214
Course Name: DYNAMICS OF MACHINES
Program & Sem: B.Tech (MEC) & V

Date: 30 December 2019
Time: 9.30 AM to 12.30 PM
Max Marks: 80
Weightage: 40%

Instructions:

(i) Read the all questions carefully and answer accordingly.

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries 3 marks. **(6Qx3M=18M)**

1. In the fig Q1, F_1=F_2=100 N, h=50mm. Find the magnitude in N-m and direction of T.

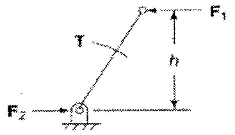


Fig Q1

(C.O.No.1) [Knowledge]

2. State the condition of equilibrium of a three force member. (C.O.No.1) [Knowledge]

3. Identify two force, three force and two forces with a torque member in the fig Q3 shown.

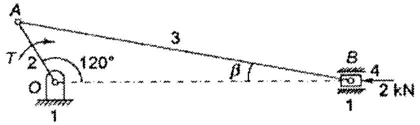


Fig Q3

(C.O.No.1) [Knowledge]

4. Draw a turning moment diagram for a single cylinder four stroke engine.
(C.O.No.2) [Knowledge]

5. The turning moment diagram for a petrol engine is drawn to the following scales: Turning moment, 1 mm = 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 mm^2. Identify the points where the energy is maximum and minimum. (C.O.No.2) [Knowledge]

the mass moment of inertia of the flywheel in kg m^2 . (C.O.No.2) [Knowledge]

Part B [Thought Provoking Questions]

Answer both the Questions. Each Question carries 10 marks. **(2Qx10M=20M)**

7. Design of governor revolves around the terms like Lift, Height of the governor, Sensitivity, Effort & Power and Controlling force. Briefly explain the terms with the help of a simple sketch and mathematical expressions wherever necessary (C.O.No.5) [Comprehension]

8. Stiffness of the spring plays an important role in providing a range of speed and stability in Spring Loaded Governors. Prove that the stiffness, with usual notations, is given by

$$2\left(\frac{F_{C2}-F_{C1}}{r_2-r_1}\right)\left(\frac{x}{y}\right)^2$$

(C.O.No.5) [Comprehension]

Part C [Problem Solving Questions]

Answer all the Questions. Each Question carries 14 marks. **(3Qx14M=42 M)**

9. 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°, find, taking friction into account, range of speed of the governor. (C.O.No.5) [Application]

10. A ship propelled by a turbine rotor which has a mass of 5 tonne and a speed of 2100 r.p.m. The rotor has a radius of gyration of 0.5 m and rotates in a clockwise direction when viewed from the stern. Find the gyroscopic effects in the following conditions: (C.O.No.4) [Application]

    i. The ship sails at a speed of 30 km/h and steers to the left in a curve having 60 m radius.

    ii. The ship pitches 6 degree above and 6 degree below the horizontal position. The bow is descending with its maximum velocity. The motion due to pitching is simple harmonic and the periodic time is 20 seconds.

    iii. The ship rolls and at a certain instant it has an angular velocity of 0.03 rad/s clockwise when viewed from stern. Explain how the direction of motion due to gyroscopic effect is determined in each case.

11. 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

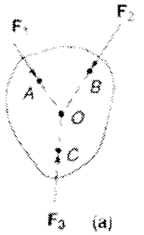
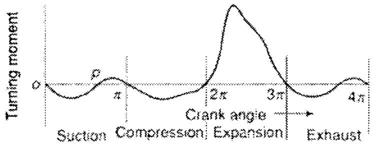
SCHOOL OF ENGINEERING

SOLUTION

Semester: Odd Sem. 2019-20
Course Code: MEC 214
Course Name: DYNAMICS OF MACHINES
Program & Sem: UG MEC & 5TH SEM

Date: xx.12.2019
Time: 3 HRS
Max Marks: 80
Weightage: 40%

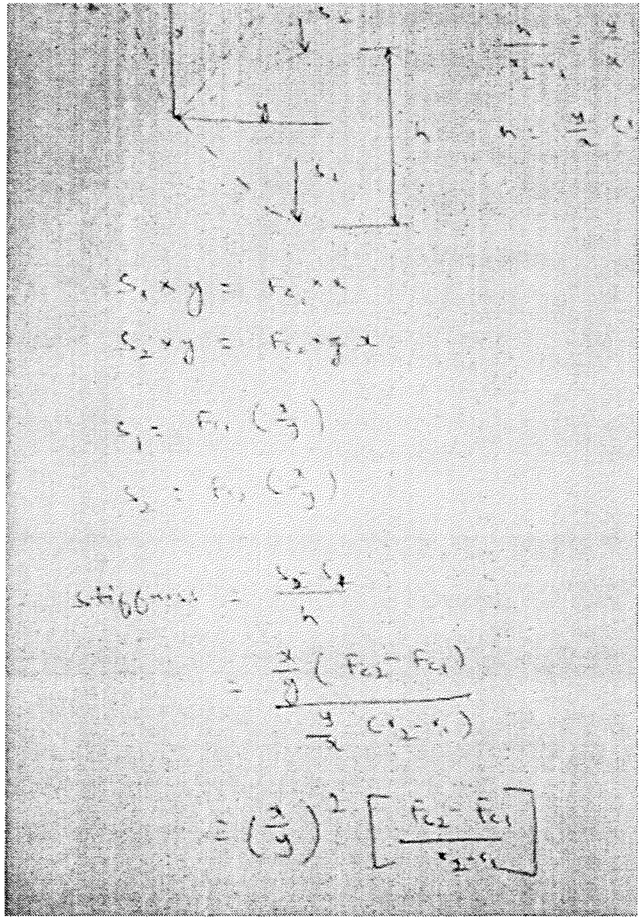
Part A (6Q x 3M = 18Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	$T = F_1 \times h = F_2 \times h$ T=100 x .050 = 5 N-m [CW]	**1+1+1**	**3 Min**
2	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*). 	**Sketch 1** **2**	**4 Min**
3	Link 2 : Two force and a torque member Link 3: Two force member Link 4 : Three force member	**3**	**2 Min**
4		**3**	**4 Min**

	Energy at G = E − 2.0 − 2.0 = E = Energy at A		
6	$E = I\omega^2 c_s$ $400 = I(20)^2(0.04)$ $I = \frac{1}{0.04} = 25$	1 1 1	4 Min

Part B (2Q x 10M = 20Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
7	<u>Height of a governor</u>. It is the vertical distance from the centre of the ball to a point where the axes of the arms (or arms produced) intersect on the spindle axis. It is usually denoted by h. Sleeve lift. It is the vertical distance which the sleeve travels due to change in equilibrium speed. Sensitiveness is defined as the ratio of the difference between the maximum and minimum equilibrium speeds to the mean equilibrium speed. Let N_1 = Minimum equilibrium speed, N_2 = Maximum equilibrium speed, and N = Mean equilibrium speed $= \frac{N_1 + N_2}{2}$. ∴ Sensitiveness of the governor $= \frac{N_2 - N_1}{N} = \frac{2(N_2 - N_1)}{N_1 + N_2}$ $= \frac{2(\omega_2 - \omega_1)}{\omega_1 + \omega_2}$ . . . (In terms of angular speeds) Effort and Power of a Governor: The effort of a governor is the mean force exerted at the sleeve for a given percentage change of speed* (or lift of the sleeve). The power of a governor is the work done at the sleeve for a given percentage change of speed. It is the product of the mean value of the effort and the distance through which the sleeve moves. Mathematically,	Definition 1X5=5M Sketch and Marking – 2M Expression for Sensitivity, Controlling force, and Power – 2 M	20 Min

	 $\frac{h}{r_2-r_1} = \frac{y}{x}$ $h = \frac{y}{x}\,($ $S_1 \times y = F_{c_1} \times x$ $S_2 \times y = F_{c_2} \times x$ $S_1 = F_{c_1}\left(\frac{x}{y}\right)$ $S_2 = F_{c_2}\left(\frac{x}{y}\right)$ stiffness $= \frac{S_2 - S_1}{h}$ $= \frac{\frac{x}{y}(F_{c_2}-F_{c_1})}{\frac{y}{x}(r_2-r_1)}$ $= \left(\frac{x}{y}\right)^2 \left[\frac{F_{c_2}-F_{c_1}}{r_2-r_1}\right]$	Sketch 2 M Moment Equations 2M Stiffness: 1M Lift 2M Ans 3M	20 Min

Part C (3Q x 14M = 42Marks)

30 Min

The minimum and maximum position of the governor is shown Fig respectively.

Let N_1 = Minimum speed, and

N_2 = Maximum speed.

From Fig. 18.7 (a), we find that minimum radius of rotation,

$$r_1 = BG = BP \tan 30° = 0.2 \times 0.5 = 0.1 \text{ m}$$

Height of the governor,

$$h_1 = PG = BP \cos 30° = 0.2 \times 0.866 = 0.1732 \text{ m}$$

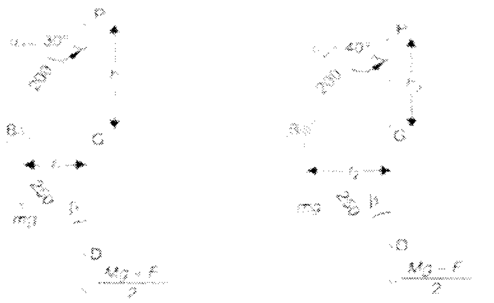
1M

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

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

and $$\tan \alpha_1 = \tan 30° = 0.5774$$

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



2M

All dimensions in mm

(a) Minimum position (b) Maximum position

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

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

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

$\therefore$ $N_1 = 183.3$ r.p.m.

Now from Fig. 18.7 (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,

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

2M

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

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

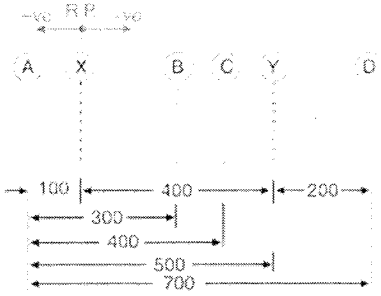
and $$\tan \alpha_2 = \tan 40° = 0.839$$

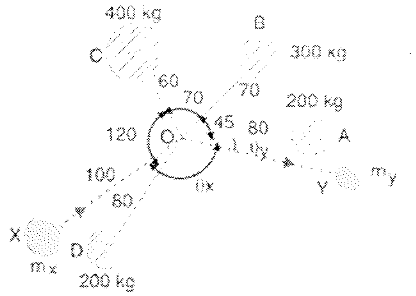
$\therefore$ $$q_2 = \frac{\tan \beta_2}{\tan \alpha_2} = \frac{0.59}{0.839} = 0.703$$

2M

	$= \frac{2\times 9.81+\left(\frac{15\times 9.81+24}{2}\right)(1-0.703)}{2\times 9.81}\times\frac{895}{0.1532} = 49\ 236$ ∴ $N_2 = 222$ r.p.m. We know that range of speed $= N_2 - N_1 = 222 - 183.3 = 38.7$ r.p.m. Ans.	2M 2M	
10	Solution. Given : $m = 5$ t $= 5000$ kg ; $N = 2100$ r.p.m. or $\omega = 2\pi \times 2100/60 = 220$ rad/s ; $k = 0.5$ m 1. *When the ship steers to the left* Given: $v = 30$ km / h $= 8.33$ m / s ; $R = 60$ m We know that angular velocity of precession, $\omega_p = v/R = 8.33/60 = 0.14$ rad/s and mass moment of inertia of the rotor. $I = m.k^2 = 5000(0.5)^2 = 1250$ kg-m^2 ∴ Gyroscopic couple, $C = I.\omega\omega_p = 1250 \times 220 \times 0.14 = 38\ 500$ N-m $= 38.5$ kN-m We have discussed in Art. 14.6, that when the rotor in a clockwise direction when viewed from the stern and the ship steers to the left, the effect of reactive gyroscopic couple is to raise the bow and lower the stern. Ans. 2. *When the ship pitches with the bow descending* Given: $\varphi = 6° = 6 \times \pi/180 = 0.105$ rad/s ; $t_p = 20$ s We know that angular velocity of simple harmonic motion, $\omega_1 = 2\pi / t_p = 2\pi / 20 = 0.3142$ rad/s and maximum angular velocity of precession, $\omega_{p_{max}} = \varphi\omega_1 = 0.105 \times 0.3142 = 0.033$ rad/s ∴ Maximum gyroscopic couple, $C_{max} = I.\omega\omega_{p_{max}} = 1250 \times 220 \times 0.033 = 9075$ N-m Since the ship is pitching with the bow descending, therefore the effect of this maximum gyroscopic couple is to turn the ship towards port side. Ans. 3. *When the ship rolls* Since the ship rolls at an angular velocity of 0.03 rad / s, therefore angular velocity of precession when the ship rolls, $\omega_p = 0.03$ rad /s ∴ Gyroscopic couple, $C = I.\omega\omega_p = 1250 \times 220 \times 0.03 = 8250$ N-m In case of rolling of a ship, the axis of precession is always parallel to the axis of spin for all positions, therefore there is no effect of gyroscopic couple. Ans.	$\omega_{p,}$ 1M I, 1M C, 2M Ans with Vector Diagram 4M Without Vector Diagram 2M 1M 2M 1M 2M	30 Min

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

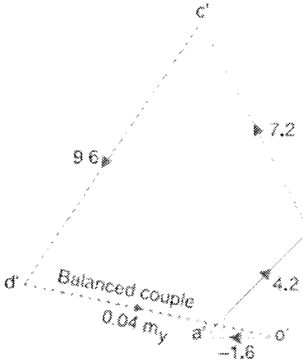


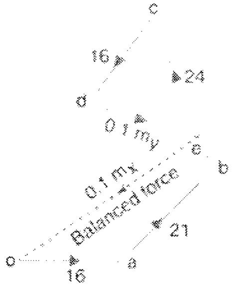


All dimensions in mm.

(*a*) Position of planes.

(*b*) Angular position of masses.





(*c*) Couple polygon

(*d*) Force polygon.

Mx=355 Kg

My=182.5 Kg

2M

Angular Positions: 2M

Vector Polygon: 3 M

Ans 1M

30 Min

Force Polygon: 3M

Ans 1M