

CS/B.Tech/ME/PE/odd/Sem-5th/ME-501/2014-15

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ME-501

DYNAMICS OF MACHINES

Time Allotted: 3 Hours

Full Marks: 70

The questions are of equal value.

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP A

(Multiple Choice Type Questions)

1. Answer all questions.

10×1 = 10

- (i) In a spring mass system with k = stiffness of spring, M = main mass and m = mass of the spring, the natural frequency is given by

- (A) $\sqrt{\frac{k}{M+m}}$ rad/s
(B) $\sqrt{\frac{k}{M+m/2}}$ rad/s
(C) $\sqrt{\frac{k}{M+m/3}}$ rad/s
(D) $\sqrt{\frac{3k}{M+m}}$ rad/s

- (ii) The natural frequency of a spring-mass system on earth is ω_n . The natural frequency of the system on the moon ($g_{moon} = g_{earth}/6$) is

- (A) ω_n
(B) $0.408\omega_n$
(C) $0.204\omega_n$
(D) $0.167\omega_n$

- (iii) Primary unbalance force is maximum when the angle of inclination of crank with the line of stroke is

- (A) 0°
(B) 90°
(C) 180°
(D) 360°

- (iv) The Proell governor as compared to Porter governor, at same speed

- (A) is more sensitive
(B) requires smaller size
(C) Less lift
(D) all of these

- (v) The engine of an aeroplane rotates in CW direction looking from the tail end. If the aeroplane takes right turn the effect of gyroscopic couple on the aeroplane will be

- (A) To raise the nose and dip the tail
(B) To dip the nose and dip the tail
(C) To raise the nose and raise the tail
(D) none of these

- (vi) The maximum fluctuation of energy in a flywheel is equal to

- (A) $I\omega(\omega_1 - \omega_2)$
(B) $I\omega^2 C_s$
(C) $2 EC_s$
(D) all of these
- where, I = mass moment of inertia of the flywheel, E = Mean kinetic energy of the flywheel, C_s = Coefficient of fluctuation of speed and ω = mean angular speed

- (vii) The factor which effect the critical speed of the shaft

- (A) Diameter of the disc
(B) Span of the shaft
(C) Eccentricity
(D) All of these

- (viii) In a vibration isolation system is ω/ω_n is greater than 1, then phase difference between the transmitted force and disturbing force is

- (A) 0°
(B) 90°
(C) 180°
(D) 270°

- (ix) The natural frequency of a system is a function of

- (A) stiffness of the system
(B) mass of the system
(C) amplitude of the oscillation
(D) both (A) and (B)

- (x) The danger of breakage and vibration is maximum

- (A) Below the critical speed
(B) Near the critical speed
(C) Above the critical speed
(D) None of these

GROUP B

(Short Answer Type Questions)

Answer any three questions.

3×5 = 15

2. A punching machine carries out 6 holes per minute. Each hole of 40 mm diameter in 35 mm thick plate requires 8 N-m of energy/mm² of the sheared area. The punch has a stroke of 95 mm. Find the power of the motor required if the mean speed of the flywheel is 20 m/s. If the total fluctuation of speed is not to exceed 3% of the mean speed, determine the mass of the flywheel.

3. (a) What is 'critical speed' of a rotating shaft?

1+4

- (b) A gun barrel weighs 300 kg and a recoil spring of stiffness 250 N/mm. The barrel recoils 0.8 m on firing. Determine the
(i) Critical recoil velocity of the gun;
(ii) Critical damping co-efficient of the dashpot engaged at the end of the recoil stroke.

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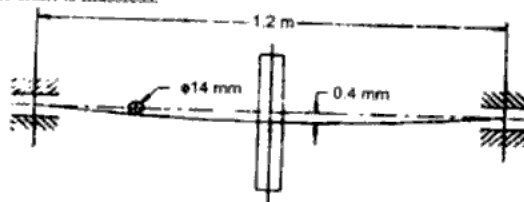
4. What is the functional difference between a Governor and a flywheel? Deduce an expression for the power of a Centrifugal governor. 2+3
5. A vertical steel shaft 15 mm diameter is held in long bearings 1 metre apart and carries at its middle a disk of mass 15 kg. Knowing the modulus of elasticity for the shaft material is 200 GPa, determine the critical speed of the shaft.
6. A spring mass system has spring stiffness s N/m and has a mass of m kg. It has the natural frequency of vibration as 12 Hz. An extra 2 kg mass is coupled to m and natural frequency reduces by 2 Hz. Find the value of s and m .

GROUP C
(Long Answer Type Questions)

Answer any three questions.

3 × 15 = 45

7. (a) A shaft of length 1.2 m and diameter 14 mm is held between two long bearings as shown in figure. A disc of mass 16 kg is kept at the middle of the shaft when its mass centre having an eccentricity of 0.4 mm forms the shaft axis. The modulus of elasticity and permissible stress of the shaft material are 200 GPa and 70×10^6 Pa respectively. Determine the critical speed of the shaft and the range of speed over which it is unsafe to run the shaft. Assume shaft is massless. 8



- (b) The turning moment diagram for a multi-cylinder engine has been drawn to a scale of 1 mm = 325 Nm vertically and 1 mm = 3° horizontally. The areas above and below the mean torque line are -26, +378, -256, +306, -302, +244, -380, +261 and -255 mm². The engine is running at a mean speed of 600 rpm. The total fluctuation of speed is not to exceed $\pm 1.8\%$ of the mean speed. If the radius of flywheel is 0.7 m, find the mass of the flywheel. 7

8. (a) What do you understand by gyroscopic couple? Derive a formula for its magnitude. 5
- (b) The rotor of the turbine of a yacht makes 1200 rpm clockwise when viewed from the stern. The rotor has a mass of 750 kg, and its radius of gyration is 250 mm. Find the maximum gyroscopic couple transmitted to the hull (body of the yacht), when the yacht pitches with maximum angular velocity of 1 rad/s. 10

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[Turn over]

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9. (a) A vertical reciprocating engine refers to the following data: 9
 - (i) crank shaft speed 1200 rpm with a stroke of 110 mm
 - (ii) connecting rod length 250 mm between centers and mass 2.25 kg
 - (iii) mass center of the connecting rod is 75 mm from crank end when suspended as pendulum from gudgeon pin makes 21 complete oscillations in 18 seconds
 - (iv) piston mass 1.8 kg
 - (v) effective gas pressure 1.8 MN/m^2 . Determine effective torque necessary to rotate the crank shaft when crank makes an angle 45° from top dead centre.

- (b) The following particulars refer to a proell governor with open arms: length of all arms = 250 mm, distance of pivot of upper arm from the axis of rotation = 40 mm, length of extension of lower arm to which each ball attached = 12 mm, the line of action of the weight of the fly ball offsets at a distance of 12 mm from the pivot where upper and lower arms joined with each other, mass of each ball = 5 g, mass of central load = 150 kg, when the arms are inclined at an angle of 40° to the axis of rotation then the radius of governor is 180 mm, find 6
 - (i) the equilibrium speed for the above configuration
 - (ii) the range of speed between which the governor is inoperative

10. (a) Explain the term 'dynamic magnifier'. What do you understand by transmissibility? 5

- (b) A body of mass 55 kg is supported by an elastic structure of stiffness 10 kN/m. The motion of the body is controlled by a dashpot which reduces its amplitude to one-tenth of its original value after two complete vibrations. Determine the damping force at 1 m/s, damping ratio and both frequency of vibration. 10

11. (a) Explain the following terms in connection with governor: 8

- (i) Sensitiveness (ii) Stability (iii) Isochronisms (iv) Hunting

- (b) The controlling force in a spring controlled governor is 1500 N when the radius of rotation of the balls is 200 mm and 887.5 when it is 130 mm. The mass of each ball is 8 kg. If the controlling force curve is straight line, determine the controlling force and the speed of rotation when the radius of rotation is 150 mm. Also find the increase in the initial tension so that the governor is isochronous. What will be the isochronous speed? 7

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