Revolving mass/cylinder = 250 kg
Reciprocating mass/cylinder = 300 kg
Length of each crank = 325 mm
Distance between wheels = 1.5 metres
Distance between cylinder centres = 1.8 metres
Diameter of the driving wheel = 1.825 metres
Radius of the balance mass = 0.76 metres
If all the revolving and 2/3rd of reciprocating masses are to be balanced, determine the magnitude and position of the balance mass in the plane of wheel. The angle between the cranks of two cylinders is 90 degree.

(1 + 2) + 9 = 12

7. (a) Four masses A, B, C and D having mass 150, 200, 300 and 250 kg are rotating in different planes at radii of 70 mm, 60 mm, 50 mm and 80 mm respectively. The distance between the planes of rotation of mass A & B is 300 mm, A & C is 400 mm and A & D is 600 mm in same direction. To make the system dynamically balanced, find the magnitude of the balancing masses and angular position if the planes of rotation of balancing masses are at 100 mm and 500 mm from A in the same direction of other masses. The radius of rotation of balancing masses is 100 mm.

   (b) Why V engines are used in some luxury cars?

10 + 2 = 12

Group – E

8. (a) Derive the relation between mean speeds of governor to its height.

   (b) A hartnell governor moves between 300 rpm and 320 rpm for a sleeve lift of 20 mm. the sleeve arms and the ball arms are 80 mm and 120 mm respectively. The levers are pivoted at 120 mm from the governor axis. The weight of each ball is 25 N. The ball arms are parallel to the governor axis at the lowest equilibrium speed. Determine
   (i) Loads on the spring at the minimum and maximum speeds
   (ii) Stiffness of the spring.

4 + 8 = 12

9. An aircraft consists of a engine and propeller of mass moment of inertia 150 kg-m^2. The engine rotates at 3600 rpm in the sense clockwise looking from the rear. The aircraft completes a half circle of radius 100 m towards left when flying at 360 km/hr. Determine the gyroscopic couple acting on the ship and its effect on the ship if
   (i) The air craft while flying at 360 km/hr turns towards right while the engine rotates at 3600 rpm in a sense clockwise looking from rear.
   (ii) The engine rotates at 3600 rpm in a sense clockwise looking from the front (nose end) and the air craft once towards left and then towards right.

12

DYNAMICS OF MACHINES
(MECH 3101)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

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

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

   (i) If the rotating mass of a rim type flywheel is distributed on another rim type flywheel whose mean radius is half the mean radius of the former, then energy stored in the latter at the same speed will be
   (a) Four times of the first one (b) Same as the first one
   (c) One fourth of the first one (d) One and a half times of the first one.

   (ii) If ω/ω_n is very high for a body vibrating under steady state vibrations, the phase angle for all values of damping factors will tend to approach
   (a) 0° (b) 90° (c) 180° (d) 360°.

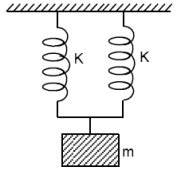
   (iii) The natural frequency of free longitudinal vibrations is equal to (where m = Mass of the body, s = Stiffness of the body, and δ = Static deflection of the body)
   (a) $\frac{1}{2\pi}\sqrt{\frac{S}{m}}$ (b) $\frac{1}{2\pi}\sqrt{\frac{g}{\delta}}$ (c) $\frac{0.4985}{\sqrt{\delta}}$ (d) Any one of these.

   (iv) The essential condition of placing the two masses, so that the system becomes dynamically equivalent, is (where l_1 and l_2 = Distance of two masses from the centre of gravity of the body, and k_G = Radius of gyration of the body)
   (a) $l_1 = k_G$ (b) $l_2 = k_G$ (c) $l_1 l_2 = k_G$ (d) $l_1 l_2 = k_G^2$

   (v) A reed type tachometer uses the principle of
   (a) Longitudinal vibration (b) Torsional vibration
   (c) Transverse vibration (d) Damped free vibration.

   (vi) In order to balance the reciprocating masses,
   (a) Primary forces and couples must be balanced
   (b) Secondary forces and couples must be balanced
   (c) Both (a) and (b)
   (d) Only primary and secondary forces must be balanced.

(vii) In the system shown in figure below, the natural frequency of vibration of the block is f. What will be the natural frequency of vibration of the block if one of the springs breaks.



(a) f (b) 2f (c) 0.5f (d) 1.5f.

(viii) The tractive force in a locomotive with two cylinders is given by (where c = Fraction of reciprocating parts per cylinder, m = Mass of reciprocating parts, ω = Angular speed of crank, r = Radius of crank, and θ = Angle of inclination of crank to the line of stroke)

(a) $m.\omega^2.r \cos\theta$ (b) $c.m.\omega^2.r \sin\theta$
(c) $(1 - c)m.\omega^2.r(\cos\theta - \sin\theta)$ (d) $m.\omega^2.r(\cos\theta - \sin\theta)$.

(ix) If the controlling force line for a spring controlled governor when produced intersects the Y-axis at the origin, then the governor is said to be
(a) Stable (b) Unstable
(c) Isochronous (d) Non-isochronous.

(x) The rotor of a ship rotates in clockwise direction when viewed from stern and the ship takes a left turn. The effect of gyroscopic couple acting on it will be
(a) To raise the bow and stern
(b) To lower the bow and stern
(c) To raise the bow and lower the stern
(d) To raise the stern and lower the bow

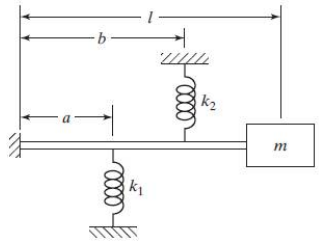
Group – B

2. (a) A single cylinder vertical engine has bore of 300 mm and a stroke of 400 mm. The connecting rod is 1m long. The mass of the reciprocating parts is 140 kg. On the expansion stroke with the crank at 30 degree from the top dead centre the gas pressure is 0.7 Mpa. If the engine runs at 250 rpm, determine,
(i) Net force acting on the piston,
(ii) Resultant load on the gudgeon pin,
(iii) Thrust on the cylinder walls, and
(iv) The speed above which, other thing remaining same, the gudgeon pin load would be reversed in direction.

(b) Why small flywheel is used in multi-cylinder engines?

10 + 2 = 12

3. (a) Find the natural frequency of vibration of mass m as shown in figure which vibrates in plane of paper.



(b) A cantilever shaft 60 mm diameter and 400 mm long has a disc of mass 80 kg at its centre. The Young's modulus for the shaft material is 200 GN/m^2. Determine the natural frequency of free vibration along longitudinal and transverse direction of the shaft.

5 + 7 = 12

Group – C

4. (a) A vibrating system consists of a mass of 15 kg, a spring of stiffness 15 KN/m and a damper. The damping provided is only 25% of the critical value. Determine the natural frequency of the damped vibration and the ratio of two consecutive amplitudes.

(b) A machine part having a mass of 3 kg vibrates in a viscous medium. A harmonic exciting force of 25 N acts on the part and causes resonant amplitude of 15 mm with a period of 0.2 second. Find the damping coefficient. If the frequency of exciting force is changed to 4Hz, determine the increase in amplitude of the forced vibrations upon the removal of the damper.

6 + 6 = 12

5. (a) In a single degree damped vibrating system, a suspended mass of 10 kg makes 20 oscillations in 15 seconds. The amplitudes decrease to 0.25 of the initial values after 6 oscillations. Determine the
(i) Stiffness of the spring
(ii) Logarithmic decrement
(iii) Damping factor.

(b) A shaft of 50 mm diameter and 3 m length has a mass of 14 kg per meter length. It is simply supported at the ends and carries three masses of 80 kg, 130 kg and 60 kg at 0.7 m, 1.6 m and 2 m respectively from the left support. Taking E = 200 GN/m^2, find the frequency of the transverse vibrations.

6 + 6 = 12

Group – D

6. (a) What is balancing and why is it necessary for high speed engines?

(b) The following particulars relate to an outside cylinder of an uncoupled locomotive: