DRONACHARYA GROUP OF INSTITUTIONS, GREATER NOIDA

Mechanical Engineering Department

Theory of Machines II (EME 603)

Set-1

Q-1 Differentiate between the functions of flywheel and a governor. Derive the expression for moment of inertia of a flywheel in terms of maximum fluctuation of kinetic energy, mean engine speed and maximum fluctuation of speed.(2004)

Q-2 The vertical scale of the turning – moment diagram for a multi-cylinder engine is 1 cm = 7000 Nm of torque and the horizontal scale is 1 cm = 30 ^{o} of crank rotation. The areas (in cm ^{2}) of the turning moment diagram above and below the mean torque line taken in order are -0.5, +1.2, -0.95, + 1.55, -0.85, +0.61, -1.06.
The engine speed is 700 rpm and it is desired that the fluctuation from minimum to maximum speed should not to be more than 2 % of the average speed. Determine the moment of inertia of the flywheel. .(2007) **(Ans. 60 kg. m2**)

Q-3 The turning moment diagram for a four stroke gas engine may be assumed for simplicity to be represented by four triangles, the areas of which from the line of zero pressure are as follows: suction stroke = 0.45 × 10 $^{-3}$ m^2 , compression stroke = 1.7 × 10 $^{-3}$ m^2 , exhaust stroke = 0.65 × 10 $^{-3}$ m^2 & expansion stroke = 6.8 × 10 $^{-3}$ m^2. Each 1 m^2 of area represent 3 MN-m of energy.
Assuming the resisting torque to be uniform, find the mass of rim of flywheel required to keep the speed between 202 and 198 r. p .m. The mean radius of the rim is 1.2 m **(Ans 1390 kg)(2003)**

Q-4 The equation of torque on the crankshaft of an engine is given by the equation. T = 10000 + 4750 Sin 2 θ – 2850 Cos 2θ N. m
Where θ is crank angle. The resisting torque is uniform.(2006)
Find: (i) Power developed **(250 k w)** (ii) Moment of inertia of flywheel if the variation of speed is not to exceed ± 2% of the mean speed which is 240 rpm. (**220 kg/ m2)** (iii) Angular acceleration of flywheel when θ = 45 ^{o} from IDC. **(22 rad/ sec 2)**

Q-5 The equation of TM curve of a three crank engine is (5000 + 1500 Sin 3 θ) N.m where θ is the crank angle in radians. The moment of inertia of the flywheel is 1000 kg. m ^{2} and the mean speed is 300 rpm. Calculate
1. Power of the engine **(Ans 160 kW)**
2. Maximum fluctuation of speed is of the flywheel in % when (i) The resisting torque is constant & **(Ans. 0.1 %)**
(ii) The resisting torque is (5000 + 600 Sin θ) N.m (**Ans. 0.08 %)**

Q-6 Why are large flywheels required for shearing / punching processes? (2009-10)
Q-7 A twin – cylinder engine is single acting with its cranks set at right angles and it runs at 1500 rpm. The torque for the power stroke with a maximum torque of 120 kgt-m at 60 ^{o} after dead centre of the corresponding crank. The torque on the return stroke is negligible. Find the horse power developed and the moment of inertia of the flywheel, if the speed is to be kept within ± 3 % of mean speed.(2009-10)

Q-8 The equation of a turning moment curve of an IC engine running at 300 rpm is given by T = 25000 + 8500 Sin 3θ N m. A flywheel coupled to the crankshaft has a mass moment of inertia 452 Kg m^2 about its axis of rotation. Determine the horse power of the engine, total fluctuation of speed and maximum angle by which the flywheel leads or lags an imaginary flywheel running at constant speed. .(2005)
(Ans. 1053.8 HP, 1.27 %, 60 ^{o}, 120 ^{o}, 180 ^{o})

Q-9 A single cylinder, single acting, four stroke gas engine develops 25 kW at 320 rpm. The work done by the gases during expansion stroke is three times the work done on the gases during the compression stroke. The work done during the suction and exhaust strokes being negligible. The fluctuation of speed is not to exceed ± 2 % of the mean speed. The turning moment *diagram during compression and expansion is assumed to be triangular in shape. Find the weight of the flywheel if its radius of gyration is 0.5*

Q-10 A single cylinder two stroke vertical engine has a bore of 30 cm & a stroke of 40 cm with a connecting rod of 80 cm long. The weight of reciprocating parts is 1350 N. when the piston is at quarter stroke and moving down, the pressure on it is 0.64 MPa. If the speed of the engine crankshaft is 350 rpm clockwise. Find the turning moment on the crankshaft. Neglect the mass & inertia effects of connecting rod and crank. (Ans $\theta = 54.3^{o}$, 6113.88 N.m)

Q-11 The turning moment diagram of an engine rotating at 200 rpm is given by relation T (kN-m) = 15 + 8 Sin 2 θ -2 Cos 2θ, where θ is the crank angle. External resistance is constant. A flywheel weighing 20 kN is fitted on the engine shaft so that the total fluctuation of speed does not exceed 1 %. Determine the least value of moment of inertia of the flywheel and its radius of gyration. (Ans. 1880.3 kg.m2), 0.9598 m)

Set-2

Q-1 Explain the terms, "static balancing "and "dynamic balancing" (2003-04)

Q-2 Derive the following expression for an uncoupled two cylinder locomotive engine:- (2003-04;04-05;05-06;07-08)
(i) Variation in tractive force (ii) Swaying Couple (iii) The hammer blow in the case of two cylinder locomotive.

Q-3 Four masses A, B, C, and D as shown below, are to be completely balanced:- (2003-04)

	A	B	C	D
Mass(kg)	-	30	50	40
Radius(mm)	180	240	120	150

The planes containing masses B and C are 300 mm apart. The angle between the planes containing B and C is 90^{o} B and C make angles of 210^{o} and 120^{o} respectively with D in the same sense. Find:-
(i) Magnitude and the angular position of mass A, (ii) The positions of planes A and D.
(Ans: 20 kg, $\theta_{AB} = 230^{o}$, L_{bd} = 0.4 m, L_{ab} -1. m)

Q-4 A rotating shaft carries four masses A, B, C and D at radii 10 cm, 12.5 cm, 20 cm and r cm respectively. The planes in which the masses revolve are spaced 60 cm apart. The masses B, C and D are known to be 10 kg, 5 kg and 4 kg respectively.
It is desired that the rotating shaft should be in complete dynamic balance. For this to be achieved, determine:
(i) Required mass A. (ii) The relative angular positions of four masses, given that the angular spacing of the planes containing C and D are 116^{o} and 260^{o} respectively relative to B measured in the same sense.
(iii) Find the radius at which D is to be placed. **(Ans: 7.5 Kg, 70^{o}, 15 mm**)

Q-5 Four masses A, B, C and D i.e. 40 kg, 50 kg, 60 kg and M kg respectively are rigidly connected to a shaft at 30 cm, 24 cm, 28 cm and 24 cm respectively from the axis of shaft. The shaft revolves about its axis and the planes of revolution of masses are at equal intervals apart. Determine M and the angular positions of B, C and D in relation to that of A in order that masses may completely balance one another. (2006-07)
(Ans: A-Horizontal, $\theta_{AB} = 240^{o}$, $\theta_{AC} = 35^{o}$, θ_{AD} =200, M_D 65 kg)

Q-6 The following data refer to two-cylinder locomotive with cranks at 90^{o}. Reciprocating mass per cylinder = 300 kg, crank radius = 0.11 m, driving wheel diameter = 1.8 m, distance between the driving wheel central planes = 1.6 m. Determine _
(i) The fraction of reciprocating masses to be balanced, if the hammer blow is not to exceed 46 KN at 96.5 Km / Hr,
(ii) The variation of tractive effort (iii) the maximum swaying couple. (2003-04) (**Ans: +-30 KN, 0.75, 10009 Nm)**

Q-7 The following data refer to a two cylinder uncoupled locomotive: (2002-03)
Rotating mass per cylinder = 280 kg, Reciprocating mass per cylinder = 300 kg
Distance between wheels = 1400 mm, Distance between cylinder centers = = 600 mm

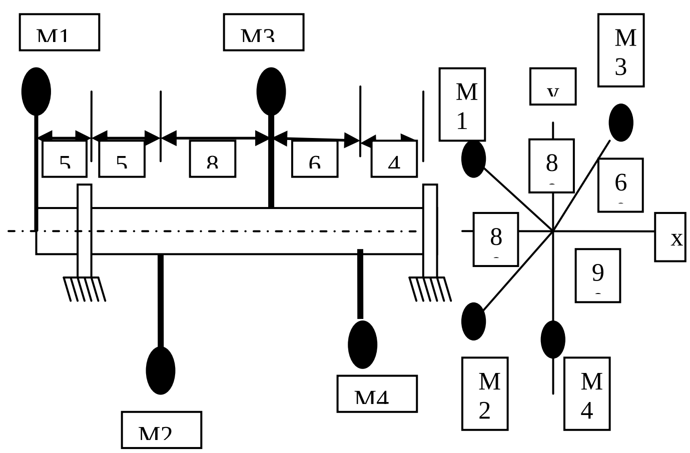
Diameter of treads of driving of treads wheels = 1800 mm, Crank radius = 300 mm
Radius of centre of balance mass = = 620 mm, Locomotive speed = 50 km / hr
Angle between cylinder cranks = 90 ^{o}, Dead load on each wheel = 3.5 tons.

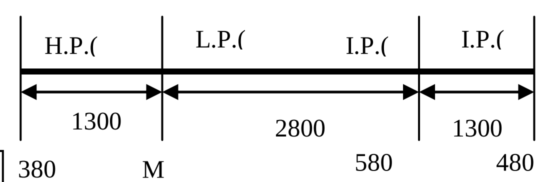
Determine (i) The balancing mass required in the plane of driving wheels, if whole of the revolving mass and 2/3 rd reciprocating mass are to be balanced. And also their position (ii) Maximum swaying couple (iii) Maximum tractive effort variation
(iv) Max & Min pressure on rail (v) Speed at which locomotive lifted from rails.
(Ans MD, MA 180 kg, θ_{12} =190 ^{o}, θ_{14} =290)

Q-8 The firing order in a six cylinder vertical four stroke in-line engine is 1-4-2-6-3-5. The piston stroke is 100 mm and the length of each connecting rod is 200 mm. The pitch distance between the cylinder centre lines are 100 mm, 100mm, 150 mm, 100mm and 100 mm respectively. The reciprocating mass per cylinder is 1 kg and the engine runs at 2500 rpm. Determine the out-of balance primary and secondary forces and couples on this engine, taking a plane midway between cylinders 3 and 4 as the reference plane.(2005-06) **(Ans: 0, 0, 0, 0)**

Q- 9 An air compressor has four vertical cylinders 1, 2, 3 and 4 in line and driving cranks at 90 ^{o} intervals reach their upper most positions in this order. The cranks are of 150 mm radius, the connecting rods 500 mm long and the cylinders centre line 400 mm apart. The mass of the reciprocating parts for each cylinder is 22.5 kg and speed of rotation is 400 rpm. Show that there are no out of balance primary or secondary forces and determine the corresponding couples, indicating the positions of No. 1 crank for maximum values. The central plane of the machine may be taken as reference plane. (**Ans: UPC -6665 Nm, USC- 2850 Nm)**

Q-10 Determine the bearing reactions for a system of four unbalance masses, shown in figure. The rotor speed is 600 r p m (2005-06) (**Ans: Ra 75350 N, Rb 21475 N)**





Q- 11A shaft carries four masses A, B,C & D of magnitude 200 kg, 300 kg, 400 kg & 200 kg respectively & revolving at radii 80 mm, 70 mm 60 mm & 80 mm in planes measured from A at 300 mm , 400 mm & 700 mm. The angles between the cranks measured anticlockwise are A to B 45^o, B to C 70 ^{o} & C to D 120 ^{o}. The balancing masses are to be placed in planes X & Y. The distance between the planes A & X is 100 mm, between X & Y is 400 mm & between Y & D is 200 mm. If the balancing masses revolve at a radius of 100 mm. Find their magnitude and angular positions. **(Ans: 355 kg, 182.5 kg)**

Q-12 *What are in- line engines? State clearly in – line four stroke and two stroke engines are balanced* (2005-06)

Q-13 *Considering the balancing of any engine you have studied derives the expressions for primary and secondary unbalanced forces.* (2004-05)

Q-14 Why is the need of balancing increasing these days? Explain in a comprehensive manner the method of balancing a number of rotating masses in one plane, by a single mass in same plane. (2006-07)

Q-15 A shaft carries four rotating masses A, B, C and D in this order along its axis. The mass A may be assumed to be concentrated at a radius of 12 cm, B at 15 cm, C at 14 cm and D at 18 cm. The masses of A, C and D are 15 kg, 10 kg and 8 kg respectively. The planes of revolution of A and B are 15 cm apart and of B and C are 18 cm apart. The angle between the radii of A and C is 90 ^{o}. If the shaft is in complete dynamic balance determine (2004-05) Find *(i) The angles between the radii of A, B and D (ii) The distance between the planes of revolution of C and D (iii) the mass B.* ***(Ans: θ_{AB} =1186.32, θ_{AD} =316 ^{o}, Lcd 7.65 cm, M_B 19.22 kg)***

Q-16 A shaft carries four masses in parallel planes A, B, C and D. The rotating masses and their eccentricity are m_b = 25 kg, e_b = 20 cm m_c = 40 kg, e_b = 10 cm m_d = 35 kg, e_d = 18 cm The mass at A has an eccentricity of 15 cm. Masses at C and D make angles of 90 ^{o} and 195 ^{o} respectively with B in the same sense. The axial distance between B and C is 25 cm. Determine the mass at A and its angular position. Also determine the positions of planes A and D. (20007-08)

(Ans: MA = 16.67 kg, θ_{AD} =98^o, L_{ab} = -40 cm L_{db} = 6.35 cm)

Q-17 A four cylinder steam engine is in complete balance. The arrangement of reciprocating masses in different planes is as shown in figure. The stroke of each piston is 2r mm. Determine the reciprocating mass of the L.P. cylinder and the relative crank position.
The angle between crank of first and third cylinder is 90 ^{o}. (Ans: 535.55 kg, ***θ_{12} =193 ^{o}, θ_{14} =286 ^{o}****)(* 2002-03)

Q-18 A shaft has three eccentrics of mass 1 kg each. The central plane of eccentrics is 50 mm apart. The distance of the centers from the axis of rotation are 20 mm, 30 mm, and 20 mm and their angular positions are 120 ^{o} apart. Find the amount of out-of balance force and couple at 600 rpm. If the shaft is balanced by adding two masses at radius of 70 mm and at a distance of 100 mm from the central plane of the middle eccentric. Find the amount of the masses and their angular positions. (2008-09)

Q-19 Three cylinder of an air compressor has their axes 120 ^{o} to one another and their connecting rods are couple to a common crank. The stroke is 100 mm and the length of each connecting rod is 150 mm. The mass of reciprocating parts per cylinder is 2 kg. Find the maximum primary and secondary forces acting on the frame of the compressor when running at 3000 rpm. (2008-09)

Q-20 A shaft carries four rotating masses A, B, C and D in this order along its axis. Masses B, C and D are 30 kg, 50 kg and 40 kg respectively and are assumed to be concentrated at radii of 18 cm , 24 cm, 12 cm and 15 cm for A, B,C and D . Planes containing B and C are 30 cm apart. The angular spacing of the planes containing C and D are 90 ^{o} and 210 ^{o} respectively relative to B measured in the same plane. If the shaft and masses are to be in complete dynamic balance, find: (2009-10)
(i) The mass and angular position of A (ii) The position of planes A and D.

Q-21 Explain primary and secondary disturbing forces. (2009-10)
A four cylinder vertical engine cranks 300 mm long. The planes of rotation of the first , third and fourth cranks are 750 mm, 1050 mm and 1650 mm respectively from that of the second crank and their reciprocating masses are 150 kg , 400 kg and 250 kg respectively. Find second cylinder and the relative angular positions of the cranks so that the engine may be in complete dynamic balance.

Q22) The cranks of a two cylinder uncoupled inside cylinder locomotive are 300 mm long. The distance between centres lines of the two cylinder 650 mm. Wheel centre lines are 1.6 m apart. Reciprocating mass per cylinder is 300 kg. Driving wheel diameter is 1.8 meters. If the hammer blow is not to exceed 45 KN at 100 km /hour, Determine: (2009-10)
(i)Fraction of reciprocating masses to be balanced.
(ii) Variation of tractive effort, and
(iii)Maximum swaying couple.
Q-23 How are the different masses rotating in different planes balanced? Also explain why only a part of the unbalanced due to
reciprocating masses is balanced by revolving masses

Q-24 The following data relate to an outside cylinder of an uncoupled locomotive:
Revolving mass per cylinder 300 kg, Reciprocating mass per cylinder 450 kg
Length of each crank 35 cm, Distance between wheels 1.6 m
Distance between cylinders centers 1.9 m, Diameter of driving wheels 2.0 m
Radius of balancing mass 0.8 m; If whole of the revolving and 2/3 of reciprocating masses are to be balanced, determine the magnitude and positions of the balancing mass required in the planes of driving wheels. Angle between the cranks of the two cylinders is 90 ^{o}.

(Ans: 285 kg, θ_{AB} =175 $_o$, θ_{AC} = 274.9 ^{o})

Set-3

Q-1 Define the following terms relating to governors:- (2003-04;04-05;05-06;06-07)
(i) Stability (ii) Sensitiveness (iii) Isochronisms (iv) Hunting (v) Effort and power of a governor.(v) Controlling force (vi) Height of governor

Q-2 State the essential difference between a Porter and a Hartnell governor. Derive the relation between the height of the governor (h) and the angular speed of the balls (ω) for a Porter governor. *(2006-07)*

Q-3 The following particulars refer to Proell governor with open arms. Length of all arms equal to 200 mm , distance of pivot of arms from the axis of rotation = 40 mm, length of extension of lower arms of which each ball is attached = 100 mm, mass of each ball is 6 kg and mass of central load = 150 Kg. If the radius rotation of the balls is 180 mm when the arms are inclined at an angle of 40 ^{o} to the axis of rotation, find the equilibrium speed for the above configuration. (2003-04)

(250 rpm)

Q-4 In a spring loaded governor of Hartnell type, the mass of each ball is 1 Kg, length of vertical arm of the bell crank lever is 100 mm and that of horizontal arm is 50 mm. The distance of fulcrum of each bell crank lever is 80 mm from the axis of rotation of the governor. The extreme radii of rotation of the balls are 75mm and 112.5 m. The maximum equilibrium speed is 5 % greater than the minimum equilibrium speed which 360 r.p.m. Find, neglecting obliquity of arms, initial compression of the spring and equilibrium speed corresponding to the radius of rotation of 100 mm**.**
(2003-04)

(30 mm, 375 rpm)

Q-5 The lengths of the upper and lower arms of a Porter governor are 20 cm and 25 cm respectively. Both the arms are pivoted on the axis of rotation. The central load is 150, N, the weight of each ball is 20 N and the friction of the sleeve together with the resistance of the operating gear is equivalent to a force of 30 N at the sleeve. If the limiting inclinations of the upper arms to be vertical are 30 ^{o} and 40 ^{o}, determine the range of speed of the governor.
(2007-08;04,05)
(225 -180 rpm)

Q-6 In a porter governor the arms and links are each 20 cm long and are hinged on the main axis. Each ball weighs 2.5 kg and central weight is 2.5 kg. The force of friction of mechanism at the sleeve is 25 N. The inclination of the arms to the vertical is 30 ^{o} and 45 ^{o} in the lowest and highest position respectively. Calculate: *(2005-06)* (i) The travel of sleeve **(65 mm)**
(ii) The speeds at the bottom, middle and the top of the travel of the sleeve, neglecting friction **(101 rpm, 106 rpm, 107 rpm)**
(iii) Same as (ii) but during upward travel taking friction into account **(125 rpm,138 rpm, 133 rpm)**
(iv) same as (iii) but during downward travel. **(72 rpm, 80 rpm, 75 rpm)**

Q-7 In a Hartnell type governor, the length of ball and sleeve arms of a bell crank lever are 150 mm and 130 mm respectively. The distance of the fulcrum of the bell crank lever from the governor axis is 14 cm. The mass of each governor ball is 5 kg. The governor runs at a mean speed of 310 rpm with the ball arms vertical and sleeve arms horizontal. For an increase of speed of 4 %, the sleeve moves 10 mm upwards. Assume sleeve mass to be 50 kg. Find: *(2005-06)* (i) The minimum equilibrium speed if the total sleeve increment is limited to 20 mm (**295 rpm)**
(ii) The spring stiffness and sensitivity of the governor **(30 N/mm, 9 %)**
(iii) When the governor is isochronous at 300 rpm what is the stiffness of the spring **(12 N/ mm)**

Q-8 In a spring loaded governor of the Hartnell type the weight of each ball is 5 kg and the lift of the sleeve is 5 cm. The speed at which the governor begins to float is 240 rpm and at this speed the radius of rotation of balls is 11 cm. The mean working speed of the governor is 20 times the range of speed when friction is neglected. If the lengths of balls and roller arms are 12 cm and 10 cm respectively and if the distance between the centre of pivot of bell crank lever and axis of governor spindle is 14 cm. Determine the initial compression of the spring taking into account obliquity of arms. If friction is equivalent to a force of 3 kg at the sleeve, find the total alteration in speed begin to move from mid position. **(7 cm 6.5 rpm)***(2006-07)*

Q-9 The radius of rotation of the balls of a Hartnell governor is 100 mm at the minimum speed of 300 rpm. Neglecting gravity effects, determine the speed after the sleeve has lifted by 50 mm. Also, determine the initial compression of the spring, governor effort and power. Take length of ball arm of lever = 150 mm, length of sleeve arm = 100 mm, weight of each ball = 40 N and stiffness of spring = 25 N/mm.(2008-09)

Q-10 For a Porter governor – All the arms of governor are 178 mm long and hinged at a distance of 38 mm from the axis of rotation. The mass of each ball is 1.15 kg and mass of sleeve is 2o kg. The governor sleeve begins to rise at 280 rpm when the links are at an angle of 30^o to the vertical. Assuming the frictional force to be constant, determine the minimum and maximum speeds of rotation when the inclination of arm to the vertical is 45 ^{o}.

(**325- 309 rpm)**

Q-11 Describe the effect of friction on the sensitiveness of a governor. *(2005-06)*

Q-12 Differentiate between the functions of the flywheels and a governor. What do you mean by inertia governors? *(2007-08)*

Q-13 A Proell governor has all four arms of length 300 mm. Upper arms are pivoted on the axis of rotation and lower arms are attached to a sleeve weighing 40 kg at a distance of 40 mm from the axis of rotation. The extensions of lower arms to which balls of weight 3.75 kg are attached are 100 mm in length. These extensions are parallel to governor axis at the minimum radius. Minimum and maximum radii are 180 and 240 mm. Find the range of governor speed. (2009-10)

Q-14 Mass of each ball in a Wilson – Hartnell governor is 2.5 kg. Length of ball arm is 100 mm whereas the sleeve arm is 80 mm long. Minimum equilibrium speed is 200 rpm; when radius of rotation is 100 mm. When the sleeve is lifted by 8 mm, equilibrium speed is 212 rpm.The stiffness of each of the springs connected to the balls is 200 N/m. The lever for the auxiliary spring is pivoted at mid point. Determine the stiffness of auxiliary spring. (2009-10)

05) Q-15 Describe Hartnell type governor with the help of a neat sketch. Derive expression for equilibrium speed. (2004-

Q-16 Explain the terms stability, hunting isochronisms and effort of governor. (2009-10)

Q-17 Prove that the sensitiveness of a proell governor is greater than that of porter governor.(2008-09)

Set-4

Q-1 The turbine rotor of a ship has a mass of 2000kg and rotates at a speed of 3000 rpm clockwise when looking from stern. The radius of gyration of the rotor is 0.5 m. Determine the gyroscopic couple and its effects upon the ship when the ship is steering to the right in a curve of 100 m radius at a speed of 16.1 knots (1 knot = 1855m/hr). Calculate also the torque and its effect when the ship is pitching in simple harmonic motion, the bow falling with its maximum velocity. The period of pitching is 50 sec. and total angular displacement between the two extreme positions of pitching is 12 ^{o}. Find the maximum acceleration during pitching motion. **(13030 N.m lowered bow, 2006 N.m, 0.001654 rad/sec ^{2})**

Q-2 The heavy turbine rotor of sea vessel rotates at 2000 r.p.m. clockwise looking from the stern, its mass being 750 kg. The vessel pitches with an angular velocity of 1 rad /sec. Determine the gyroscope couple transmitted to the hull, when bow is rising, if the radius of gyration for the rotor is 250 mm. Also show, in what direction the couple acts on the hull. *(2003-04)*

(9 9817 N.m)

Q-3 A four-wheel motor car of mass 2000 kg has a wheel base2.5 m, track width 1.5 m, and the height of C.G. 500 mm above the ground level and lies at 1 m from the front axel. Each wheel has an effective dia. o f 0.8 m and M.I. of 0.8 kg m^2. The drive shaft, engine flywheel and transmission are rotating at 4 times the speed of road wheel, in clockwise direction when viewed from the front and is equivalent to a mass of 75 kg having a radius of gyration of 100 mm. If the car is taking a right turn of 60 m radius at 60 km / hour, find the load on each wheel**.***(2003-04)***(4322 N, 7449 N, 2360 N, 5487 N)**

Q-4 Explain working principle of a mechanical gyroscope with the help of neat sketch. Briefly explain various terms associated with it. *(2004-5)*

Q-5 What do you understand by gyroscope couple? Derive the formula for its magnitude. Explain the effect of the gyroscope couple on the reaction of the four wheels of a vehicle negotiating a curve. *(2006-7;7-8)*

Q-6 The engine and the propeller of an aero plane weigh 5 kN and the radius of gyration is 50 cm. The propeller rotates at 3000 r.p.m in clockwise direction looking from the rear. If the aero plane makes quarter of a circle of radius 100 m towards left hand side while flying at 240 km / hr, what gyroscopic couple will act on the aero plane frame and what will be its effect ? *(2006-7)*

(26688 N.m)

Q-7 How is the stability of moving vehicles (4 wheeler), which is taking a turn, ascertained? What are the various factors affecting the stability?

(2005-6)

Q-8 A motor cycle along with the rider has a mass 310 kg and the system centre of gravity is 60 cm above the ground level. Each wheel of the machine has a mass of 10 kg, radius 30 cm and radius of gyration 25 cm. The rotating parts of the engine have equivalent mass 15 kg and radius of gyration 8 cm and they rotate in the same direction as the road wheels. The gear ratio from wheel to engine is 1:8. Calculate the angle of bending necessary for the machine to ride normal to the banked track on a bend of 890 m radius at a speed 150 kmph. *(2005-6)* **(66.81 ^{o})**

Q-9 A coil of spring stiffness 4 N/mm supports vertically a mass of 20 kg at the free end. The motion is resisted by the oil dashpot. It is found that the amplitude at beginning of the fourth cycle is 0.8 times the amplitude of previous vibration. Determine the damping force per unit velocity and also find the ratio of frequency of damped and undamped vibrations

(20N.s /m, 0. 99937)

Q-10 The measurement on a mechanical vibrating system shows that it has a mass of 8 kg and that the spring can be combined to give an equivalent spring of stiffness 5.4 N/ mm. If the vibrating system has a dashpot attached which exert a force of 40 N when the mass has a velocity of 1 m/sec. find critical damping coefficient, damping factor logarithmic decrement and ratio of two consecutive amplitudes**.** *(2003-04;6-7)***(415 N.s/m, 0.0962, 0.607, 1.835)**

Q-11 A vibratory system has the following data: M = 20 kg, K = 8000 N/m, C = 130 Ns/m

Determine damping factor, the natural frequency of damped oscillation, logarithmic decrement and ratio of any two successive amplitudes. Also derive the expression for logarithmic decrement. *(2004-5)* **(0.1625, 19.734 rad/sec, 1.0348, 2.8145)**

Q-12 An automobile wheel and tire are suspended by a steel rod of 0.50 cm in diameter and 2 m long. When the wheel is given an angular displacement and released, it makes 10 oscillations in 30 seconds. Determine the moment of inertia of wheel and tyre. *(2004-5)*TakeG = 80 X 10 ^{9} N/ m^{2} (**(0.56 kg.m^{2})**

Q-13 A mass of 0.907 kg is added to the end of a spring with a stiffness of 7 N/ cm. The system also has damper which is critically damped. Determine the critical damping coefficient. *(2004-5)*

(50.394 N.s/m)

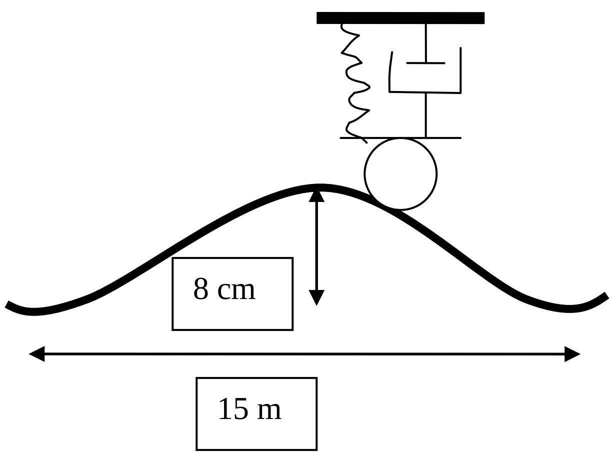
Q-14 Explain with the help of graphs, the variation in amplitude of force undamped vibrations, with change in angular velocity when periodic force is constant in magnitude. *(2005-6)*

Q-15 Define the following *(2003-0;7-84)*

(i) Degree of freedom (ii) Principal modes of vibrations (iii) Damped vibrations (iv) Critical speeds (IV) Logarithmic decrement(derive it)

Q-16 Define logarithmic decrement. Show that the logarithmic decrement is given by $\delta = \frac{1}{n}\ln(X0/Xn)$ Where Xn = amplitude after n cycles have elapsed. *(2007-8)*

Q-17 The static deflection of an automobile on its springs is 10 cm. Find the critical speed when the automobile is traveling on a road. Figure 3, which can be approximated by a sine wave, can be approximated by sine wave 8 cm amplitude and wavelength 15 m. Assume the damping ratio to be 0.05. Also determine the amplitude of vibration at 75 kmph. (84.91 kmph, 33.385 cm.) *(2005-6)*

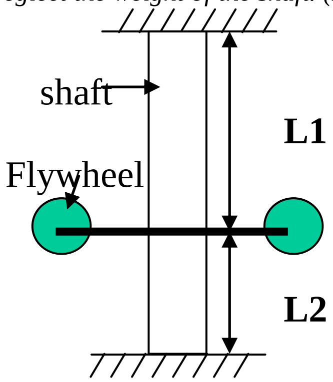


Q-18 Explain the difference between Gyroscope Couple and Reaction Couple. (2009-10)

Q-19 A ship has a propeller of mass moment of inertia 2000 kg.m^{2}. It rotates at 360 rpm in clockwise sense looking from stern. Determine the gyroscope couple and its effect when ship moves at 30 km / hr and steers to left with a radius of 200 m. (2009-10)

Q-20 Differentiate between Free and Forced vibration. What happens when free vibrations are dampened? (2009-10)

Q-21A flywheel of mass 750 kg is mounted on a vertical shaft of diameter 50 mm. Both ends of the shaft are fixed as shown in the sketch L1 = 1350 mm, L2 = 900 mm If E = 200 GPA. Find natural frequency of longitudinal vibration. Neglect the weight of the shaft. (2009-10)



Q-22 Find the logarithmic decrement and the ratio of two consecutive amplitudes of a vibrating system which consist of a mass of 3.5 kg., a spring stiffness of 25 N / mm and a damper with a damping coefficient of 0.018 N / mm/s. (2009-10)

Q-23 Describe the gyroscope effect on sea going vessels.(2003-04)

Q-24 Explain the term "Damped ". Prove the equation of motion for a damped vibration is given by

$\ddot{x} + \frac{C}{m}\dot{x} + \frac{S}{m}x = 0$ *, where x, C, m and S has standard notation. .(2003-4)*

Q-25 A gyro wheel of mass 0.6 kg and radius of gyration 20 mm is mounted in a pivoted frame. The axis of the pivots passes through the centre of rotation of the wheel, but the centre of gravity "G" of the frame is 10 mm below the centre of rotation "O". The frame has a mass of 0.25 kg and the speed of rotation of the wheel is 3000 rpm in counter clockwise direction. If the vehicle travels at 15 m / s in a curve of 60 m radius, find the inclination of the gyro wheel from the vertical, when(2008-9)

(i) The vehicle moves forward taking a left hand turn along curve and

(ii) The vehicle moves in opposite direction.

Set 5

Q-1 A single plate clutch, effective on both sides is required to transmit 25 KW at 300 rpm. Determine the outer & inner radius of frictional surface if the coefficient of friction is 0.255, the ratio of radii is 1.25 & the maximum pressure is not to exceed 0.1 N/ m^2. Also determine the axial thrust to be provided by springs.

(Ans: - 96 mm, 120 mm, 1447 N)

Q-2 Determine for an open belt drive the width of a 9.5 mm thick leather belt required to transmit 15 HP from a motor running at 750 rpm. Diameter of driving pulley of the motor is 30 cm. The driven pulley runs at 250 rpm and the distance between the centers of the two pulleys is 3 m. neglect the sag of the belt and assume no slip.
Mass of leather = .0001 kg/ cm^3, Maximum tension allowable in leather = 246 N/ cm^2, $\mu = 0.30$
(Ans: 70 cm)

Q-3 The thrust of a propeller shaft in a main engine is taken up by a number of collars integral with the shaft which is 300 mm in diameter. The thrust on the shaft is 200 KN & the speed is 75 rpm. Taking, $\mu = 0.05$ & assuming intensity of pressure as uniform & equal to 0.3 N/ mm2. Find the external diameter of the collars required, if the power lost in friction is not to exceed 16 KW.

(Ans: 496 mm, 6)

Q-4 A transmission shaft, rotating at 500 rpm, drives a milling machine which requires 3.75 kW at 750 rpm. A 300 mm diameter cast iron pulley is mounted on the transmission shaft. A preliminary design proposes using a belt 4.75 mm thick, which has a density of 970 kg/m 3. The allowable stress is 2 MPa. The pulleys rotate in opposite directions and the centre distance of the shaft is 750 mm. The coefficient of friction is 0.3 for both the pulleys. Determine the width of the belt.

(Ans: 76 mm)

Q-5 How is dynamometers classified? What is the difference between absorption and transmission type of dynamometers? Explain with the help of diagram, any one transmission type of dynamometer.

Q-6 A porter governor has equal arms each 250 mm long & pivoted on the axis of rotation. Each ball has a mass of 5 kg & the mass of the central load on the sleeve is 25 kg. The radius of rotation of the ball is 150 mm when the governor begins to lift & 200 mm when the governor is at maximum speed. Find the range of speed, sleeve lift, governor effort & power of the governor in the following cases.

(i) When the friction at the sleeve is neglected **(Ans : 25 rpm, 0.1 m, 48.28 N,)**

(ii) When the friction at the sleeve is equivalents to 10 N **(Ans : 31.4 rpm, 0.1 m 65.1 N, 6.5 Nm.)**

Q-7 In a Hartnell type governor, the length of ball and sleeve arms of a bell crank lever are 150 mm and 130 mm respectively. The distance of the fulcrum of the bell crank lever from the governor axis is 14 cm. The mass of each governor ball is 5 kg. The governor runs at a mean speed of 310 rpm with the ball arms vertical and sleeve arms horizontal. For an increase of speed of 4 %, the sleeve moves 10 mm upwards. Assume sleeve mass to be 50 kg. Find:

(i) The minimum equilibrium speed if the total sleeve increment is limited to 20 mm (**295 rpm)**

(ii) The spring stiffness and sensitivity of the governor **(30 N/mm, 9 %)**

(iii) When the governor is isochronous at 300 rpm what is the stiffness of the spring **(12 N/ mm)**

Q-8 Define the following terms relating to governors:-

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

Q-9 The following particulars refer to Proell governor with open arms. Length of all arms equal to 200 mm , distance of pivot of arms from the axis of rotation = 40 mm, length of extension of lower arms of which each ball is attached = 100 mm, mass of each ball is 6 kg and mass of central load = 150 Kg. If the radius rotation of the balls is 180 mm when the arms are inclined at an angle of 40^{o} to the axis of rotation, find the equilibrium speed for the above configuration. **(250 rpm)**

Q-10 A shaft carries four masses in parallel planes A, B, C and D. The rotating masses and their eccentricity are $m_b = 25$ kg, $e_b = 20$ cm $m_c = 40$ kg, $e_b = 10$ cm $m_d = 35$ kg, $e_d = 18$ cm The mass at A has an eccentricity of 15 cm. Masses at C and D make angles of 90^{o} and 195^{o} respectively with B in the same sense. The axial distance between B and C is 25 cm. Determine the mass at A and its angular position. Also determine the positions of planes A and D. (**Ans: MA = 16.67 kg, θ_{AD} =98^{o}, L_{ab} = -40 cm L_{db} = 6.35 cm)**

Q-11 The following data refer to a two cylinder uncoupled locomotive:

Rotating mass per cylinder = 280 kg, Reciprocating mass per cylinder = 300 kg
Distance between wheels = 1400 mm, Distance between cylinder centers = = 600 mm
Diameter of treads of driving of treads wheels = 1800 mm, Crank radius = 300 mm
Radius of centre of balance mass = = 620 mm, Locomotive speed = 50 km / hr
Angle between cylinder cranks = 90^{o}, Dead load on each wheel = 3.5 tons.

Determine (i) The balancing mass required in the plane of driving wheels, if whole of the revolving mass and 2/3 rd reciprocating mass are to be balanced. And also their position (ii) Maximum swaying couple (iii) Maximum tractive effort variation. **(Ans MD, MA 180 kg, θ_{12} =190 ^{o}, θ_{14} =290)**

Q- 12 An air compressor has four vertical cylinders 1, 2, 3 and 4 in line and driving cranks at 90^{o} intervals reach their upper most positions in this order. The cranks are of 150 mm radius, the connecting rods 500 mm long and the cylinders centre line 400 mm apart. The mass of the reciprocating parts for each cylinder is 22.5 kg and speed of rotation is 400 rpm. Show that there are no out of balance primary or secondary forces and determine the corresponding couples, indicating the positions of No. 1 crank for maximum values. The central plane of the machine may be taken as reference plane.

(**Ans: UPC -6665 Nm, USC- 2850 Nm)**

Q-13 The equation of a turning moment curve of an IC engine running at 300 rpm is given by T = 25000 + 8500 Sin 3θ N m. A flywheel coupled to the crankshaft has a mass moment of inertia 452 Kg m^2 about its axis of rotation. Determine the horse power of the engine, total fluctuation of speed and maximum angle by which the flywheel leads or lags an imaginary flywheel running at constant speed.

(Ans. 1053.8 HP, 1.27 %, 60 ^{o}, 120 ^{o}, 180 ^{o})

Q-14 In a turning moment diagram , the areas above and below the mean torque line taken in order are 395 , 785, 140, 440, 1060 and 370 mm ^{2} , having scales of 1 mm = 5 N.m and 1mm = 10 o along Y and X axes respectively. Find mass of flywheel at a radius of gyration 150 mm and maximum fluctuation of speed is limited to ± 1.5 % of mean speed which is 1800 rpm.

(Ans: 39.5 kg)

Q-15 The crank and connecting rod of a petrol engine running at 1800 rpm are 50 mm and 200 mm respectively. The dia of piston is 80 mm and the mass of the reciprocating parts is 1 kg. At a point during power stroke the pressure on the piston is 0.7 N/mm^2, when it has moved 10 mm from I D C. Determine
1. Net load on the gudgeon pin (**Ans. 1850 N);** 2. Thrust in the connecting rod **(Ans. 255 N**)
3. Reaction between the piston and cylinder **(Ans. 1870 N);** 4. The engine speed at which the above values become zero. **(Ans. 275 rad / sec.)**

Q- 16 Four masses A, B, C and D i.e. 40 kg, 50 kg, 60 kg and M kg respectively are rigidly connected to a shaft at 30 cm, 24 cm, 28 cm and 24 cm respectively from the axis of shaft. The shaft revolves about its axis and the planes of revolution of masses are at equal intervals apart. Determine M and the angular positions of B, C and D in relation to that of A in order that masses may completely balance one another. **(Ans: A-Horizontal, θ_{AB} =240^o, θ_{AC} = 35 ^{o}, θ_{AD} =200, M_D 65 kg)**

Q-17 During a trial on steam engine it is found that the acceleration of the piston is 36 m/ s^2 when the crank has moved 30^o from IDC. The net effective steam pressure on the piston is 0.5 N/ mm^2 and the frictional resistance is equivalent to a force of 600 N. The diameter of the piston is 300 mm and the mass of the reciprocating part is 180 kg. If the length of the crank is 300 mm and the ratio of connecting rod length to crank length is 4.5 Find:
(i) Reaction on crank guides; (ii) Turning moment on the crank shaft (**Ans 280 N, 5060 Nm)**