AKSHEYAA COLLEGE OF ENGINEERING

UNIT-1 - FORCE ANALYSIS

Part –B Questions

1. For a reciprocating engine, derive the expressions for: (i) Velocity and acceleration of the piston, and (ii) Angular velocity and angular acceleration of the connecting rod.
2. In a slider crank mechanism, the length of the crank and connecting rod are 150 mm and 600 mm respectively. The crank makes an angle of 60^o with the IDC and revolves at a uniform speed of 300 r.p.m. Find, by analytical method: (i) velocity and acceleration of the slider, and (ii) angular velocity and angular acceleration of the connecting rod.
3. In a slider crank mechanism, the crank and the connecting rod are 200 mm and 800 mm respectively. Determine the crank angle at which the velocity of the piston is maximum and the maximum velocity of the piston. Assuming that the crankshaft rotates at a mean speed of 300 r.p.m.
4. A vertical petrol engine 150 mm diameter and 200 mm stroke has a connecting rod 350 mm long. The mass of the piston is 1.6 kg and the engine speed is 1800 rpm. On the expansion stroke with crank angle 30^o from the top dead centre, the gas pressure is 750 kN/m^2. Determine the net thrust on the connecting rod and torque on the crank. (Dec 2003)
5. A vertical single cylinder gas engine has a bore of 8 cm and a stroke of 10 cm. The connecting rod length is 20 cm and the reciprocating parts weigh 1.5 kg. The gas pressure on the piston is 6 kg/cm^2 when it has moved 1.5 cm from the inner dead center on its power stroke. Determine the net load on the gudgeon pin when the engine runs at 2000 rpm. At what speed this load will be zero ? (May 2004)
6. The crank and connecting rod of a reciprocating engine are 150 mm and 600 mm respectively. The crank makes an angle of 60^o with the inner dead centre and revolves at a uniform speed of 300 r.p.m. Find by Klein's construction or otherwise (i) velocity and acceleration of the piston, (ii) velocity and acceleration at the midpoint of the connecting rod, and (iii) angular velocity and acceleration of the connecting rod (May 2005)
7. The lengths of crank and connecting rod, of a horizontal reciprocating engine are 200 mm and 1.0 meter respectively. The crank is rotating at 400 r.p.m, when the crank has turned through 30^o from the inner dead centre, the difference of pressure between cover end and piston rod is 0.4 N/mm2. If the mass of the reciprocating parts is 100 kg and cylinder bore is 0.4 meters, then calculate: (i) inertia force, (ii) force on piston, (iii) piston effort, (iv) thrust on the sides of the cylinder walls, (v) thrust in the connecting rod, and (vi) crank effort. (Dec 2005)
8. Deduce the expression for the inertia force in the reciprocating force neglecting the weight of the connecting rod. (8)
9. A vertical petrol engine with cylinder of 150 mm diameter and 200 mm stroke has a connecting rod of 350 mm long. The mass of the piston is 1.6 kg and the engine speed is 1800 rpm. On the expansion stroke with crank angle 30^o.from TDC, the gas pressure is 750 KPa. Determine the net thrust on the piston. (May 2006) (8)
10. A single-cylinder vertical engine has a bore of 300 mm and a stroke of 400 mm. The connecting rod is 1 m long and the mass of the reciprocating parts is 140 kg. On the expansion stroke, with the crank at $30^o$from the top dead center, the gas pressure is 0.7 MPa. If the engine runts 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 things remaining the same, the gudgeon pin load would be reversed in direction. (Dec 2006)
11. In a reciprocating engine mechanism, if the crank and the connecting rod are 300 mm and 1 m long respectively and the crank rotates at a constant speed of 200 r.p.m. Determine analytically: (i) the crank angle at which the maximum velocity occurs, and (ii) maximum velocity of the piston(iii)derive the relevant equations. (Dec 07)
12. A vertical double-acting steam engine has a cylinder 300 mm diameter and 450 mm stroke and runs at 200 rpm. The reciprocating parts has a mass of 225 kg and the piston rod is 50 mm diameter. The connecting rod is 1.2 m long. When the crank has turned through $125^o$from the top dead centre the steam pressure above the piston is 30 KN/m^2 and below the piston is 1.5 KN/m^2. Calculate: (i) crank-pin effort, and (ii) the effective turning moment on the crank shaft. (Dec 07)

13. The length of crank and connecting rod of a vertical reciprocating engine are 300 mm and 1.5 m respectively. The crank is rotating at 200 rpm clockwise. Find analytically, (i) acceleration of piston, (ii) velocity of piston, (iii) angular acceleration of the connecting rod when the crank has turned through 40 degree from the top dead centre and the piston is moving downwards. (May 2008)
14. The length of crank and connecting rod of a horizontal reciprocating engine are 200 rpm and 1.0 m respectively. The crank is rotating at 400 r.p.m. When the crank has turned 30^o front the inner dead centre, the difference of pressure between the cover end and piston end is 0.4 N/mm^2. If the mass of the reciprocating parts is 100 kg and cylinder bore is 0.4 m, then calculate: (i) inertia, (ii) force on piston, (iii) piston effort, (iv) thrust on the sides of cylinder walls, (v) thrust in the connecting rod. (Dec 2008)

15. The torque delivered by a two-stroke engine is represented by T= (1000 + 300 sin 2θ- 500 cos 2θ) N-m where θ is the angle turned by the crank from the inner-dead centre. The engine speed is 250 rpm. The mass of the flywheel is 400 kg and radius of gyration 400 mm. Determine: (i) the power developed, (ii) the total percentage fluctuation of speed, (iii) the angular acceleration of flywheel when the crank has rotated through an angle of 60^o from the inner dead centre. (iv) the maximum angular acceleration and retardation of the flywheel. (May 2003)
16. The torque exerted on the crank shaft of a two stroke engine is given by T : 7000+1000sin2θ - 2000cos2θ, where θ is crank angle from inner dead centre. Assuming resisting torque to be constant, determine: (i) power developed when engine speed is 300 rpm. (ii) the maximum fluctuations in speed in percentage. The mass of flywheel is 500 kg with radius of gyration 750 mm. (Dec 2003)
17. A vertical double-acting steam engine develops 75 kN at 250 r.p.m. The maximum fluctuation of energy is 30 percent of the work done per stroke. The maximum and minimum speeds are not to vary more than l% on either side of the mean speed. Find the mass of the flywheel required if the radius of gyration is 0.6 meters. (May 2005)
18. Define coefficient of fluctuation of speed and coefficient of fluctuation of energy.
19. The radius of gyration of a fly wheel is 1 meter and the fluctuation of speed is not to exceed 1% of the mean speed of the flywheel. If the mass of the flywheel is 3340 kg and the steam engine develops 150 kW at 135 rpm, then find (i) maximum fluctuation of energy, and (ii) coefficient of fluctuation of energy. (May 2006)
20. Define coefficient of fluctuation of energy and coefficient of fluctuation of speed and deduce suitable expressions for them.
21. The equation of turning moment diagram for the three crank engine is given by T = 25000 - 7500 sin 3θ N.m, where θ is the crank angle in radians from the inner dead centre. The moment of inertia of the flywheel is 400 $kg-m^2$ and the mean engine speed is 300 rpm. Calculate the power of the engine and the total percentage fluctuation of speed of the flywheel if the resisting torque is constant and the resistive torque in N.m is 25000 + 3600 sin θ. (Dec 2006)
22. The turning moment diagram of an engine rotating at 200 rpm is expressed as T (kN-m) = 15+8 sin2θ - 2cos 2θ where θ is the crank angle. The external resistance is found to be constant. A flywheel weighing 20 kN is fitted on the engine shaft so that the total fluctuation of speed does not exceed 1%. Evaluate the least value of moment of inertia of the flywheel and the radius of gyration. (May 2007)
23. A single cylinder, single acting, four stroke cycle gas engine develops 20 kW at 200 r.p.m. The work done by the gases during the expansion stroke is 3 times the work done on the gases during the compression stroke. The work done on the suction and exhaust strokes may be neglected. If the flywheel has a mass of 1000 kg and has a radius of gyration of 0.6 m, find the cyclic fluctuation of energy and the coefficient of fluctuation of speed. (Dec 2008)
24. The turning moment diagram for a multi-cylinder engine has been drawn to a scale of 1 mm=325 N.m vertically and 1 mm=3^o horizontally. The areas above and below the mean torque line are -26, +378, -256, +306, -302, +244, -380, +261 and -225 mm^2. The engine is running at a mean speed of 800 r.p.m. The total fluctuation of speed is not to exceed ±1.6% of the mean speed. If the radius of flywheel is 0.7 m, find the mass of the flywheel. (May 2009)

25. The crank and connecting rod of a period engine, running at 1800 rpm are 50 mm and 200 mm respectively. The diameter of the piston is 80 mm and the mass of the reciprocating parts is 1 kg at a point during the power stroke, the pressure on the piston is 0.7N/mm^2. When it has moved 10 mm from the inner dead centre. Determine the net load on the gudgeon pin, trust on the connecting, reaction between the piston and the cylinder and the engine speed at which the above values become zero. (Nov 2011)
26. A three cylinder single acting engine has its crank set equally at 120^o and it runs at 600 rpm. The torque vs crank angle diagram for each cycle is a triangle for the power stroke with a maximum torque of 90 N-m at 60^o from dead centre of corresponding crank. The torque on return stroke is sensibly zero. Determine the power developed, co-efficient of fluctuation of speed, if the mass of the fly wheel is 12 kg and a radius of gyration of 80 mm, coefficient of fluctuation of energy and maximum angular acceleration of the fly wheel. (Nov 2011).
27. The turning moment diagram for a multi cylinder engine has been drawn to a scale 1 mm = 600 N m vertically and 1mm 3^o horizontally. The intercepted area between the output torque curve and the mean reactance line, taken in order from one end are, as follows: +52,-124, +92, -140, +85, -72 and +107 mm^2, when it is running at a speed of 600 rpm. If the fluctuation of speed is not to exceed ±1.57 % of the mean, find the necessary mass of the fly wheel of radius 0.5 m.(8) (May 2012).
28. A punching press is driven by a constant torque electric motor. The press is provided with a flywheel that rotates at maximum speed of 225 rpm. The radius of gyration of the flywheel is 0.5 m. The press punches 720 holes per hour; each punching operation takes 2 seconds and requires 15 kN-m of energy. Find the Power of the motor and the minimum mass of the flywheel if speed of the same is not to fall below 200 r.p.m. (8) (May 2012).
29. The crank pin circle radius of a horizontal engine is 300mm, the mass of the reciprocating parts is 250kg. when the crank has travelled 60^0 from I.D.C. the difference between the driving and back pressure is 0.35 N/mm^2. The connecting rod length between centre, is 1.2 m and cylinder bore is 0.5m, if the engine runs at 250rpm and if the effect of piston rod diameter is neglected, calculate (i) pressure on slider bars, (ii) thrust in the connecting rod, (iii) tangential force on the crank –pin and (iv) turning moment on the crank shaft. **(APRIL /MAY 2010)**
30. The lengths of crank and connecting rod of horizontal steam engine are 300 mm and 1.2 respectively. When the crank has moved 30^0 from the inner dead center, the acceleration of piston is 35 m/s^2. The average frictional resistance to the motion on piston is equivalent to a force of 550N and net effective stream pressure on piston is 500 kN/m^2. The diameter of piston is 0.3 m and mass of reciprocating parts is 160kg. Determine (i) reaction on the cross –head guides, (ii) thrust on the crank-shaft bearing,(iii) torque on the crank shaft. (**NOVEMBER /DECEMBER 2010)**
31. The torque delivered by two stroke engine is represented by T = (1000+300 sin 2θ-500 cs2θ) N-m. where θ is the angle turned by the crank from the inner dead center. The engine speed is 250 rpm. The mass of the flywheel is 400 kg and radius of gyration 400 mm. Determine (i) the power developed (ii) the total percentage fluctuation of speed. (iii) the angular acceleration of flywheel when the crank has rotated through an angle of 60^0 from the inner dead center, and (iv) the maximum angular acceleration and retardation of the flywheel. (**NOVEMBER /DECEMBER 2010)**
32. Deduce an expression for the inertia force in the reciprocating parts, neglecting the weight of the connecting rod.**(NOVEMBER /DECEMBER -2012)**
33. The turning moment curve for an engine is represented by the equation, T= (20,000+9500 sin 2θ - 5700 cos 2θ) N-m. Where θ is the angle moved by the crank from inner dead centre. If the resisting torque is constant, find. (i) power developed by the engine. (ii) moment of inertia of flywheel in kg-m^2 , if the total fluctuation of speed is not to exceed 1% mean speed which is 180 rpm. And (iii) angular acceleration of the flywheel when the crank has turned through 45^0 from the dead centre. **(NOVEMBER /DECEMBER -2012)**
34. A shaft fitted with a flywheel rotates at 250 rpm and drives a machine. The torque of machine varies in a cyclic manner over a period of 3 revolutions. The torque rises from 750 N-m to 300 N-m uniformly during ½ revolution and remains constant for the following revolution. It then falls uniformly to 750 N-m during the next ½ revolution and remains constant for one revolution the cycle being repeated thereafter. Determine the power required the drive the machine and percentage fluctuation in speed, if

the driving torque applied to the shaft is constant and the mass of the flywheel is 500 kg with radius of gyration of 600mm. **(MAY/JUNE 2013)**

35. A horizontal steam engine running at 240 rpm has a bore of 300 mm and stroke 600 mm. The connecting rod is 1.25m long and the mass of reciprocating parts is 60 kg. when the crank is 60^0 past its inner dead centre, the steam pressure on the cover side of the piston is 1.125 N/mm^2 while that on the crank side is 0.125 N/mm^2 . Neglecting the area of the piston rod determine, (i) the force on the piston rod, and (ii) the turning moment on the crankshaft.**(MAY/JUNE 2013)**
36. The equation of the turning moment curve of a three crank engine is (5000+1500 sin 3θ) N-m where is the crank and in radians. The moment of inertia of the flywheel is 1000 kg-m^2 and the mean speed is 300 rpm . Calculate. (i)Power of the engine, and (ii) The maximum fluctuation of the speed of the flywheel in percentage when (1) The resisting torque is constant and (2), The resisting torque is (5000+600 sinθ) N-m.**(November/DECEMBER-2014) (16)**
37. Certain machine requires a torque of (5000+500 sinθ) N-m to drive it, where θ is the angle of rotation of shaft measured from certain datum. The machine is directly coupled to an engine which produces a torque of (5000+600 sin2θ) N-m. The flywheel and the other rotating parts attached to the engine have a mass of 500kg at a radius of gyration of 0.4m. If the mean speed is 150 r.p.m. find. (i) The fluctuation of energy,(ii) The total percentage fluctuation of speed, and (iii) The maximum and minimum angular acceleration of the flywheel and the corresponding shaft position.**(Nov/DEC-2014) (16)**
38. (a) Derive the equation of forces on the reciprocating parts of an engine, neglecting the weight of the connecting rod. (b) What is turning moment diagram and draw it's for four stroke IC engine?(Nov/DEC-2013) **(16)**
39. A single cylinder, single acting, four stroke gas engine develops 25 KW at 320 rpm. The work done by the gases during the expansion stroke is three times the work done on the gases during the compression stroke. The work done during the suction and exhaust stroke 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. Fine the weight of the flywheel if its radius of gyration is 0.5m. **(November/DEC-2013) (16)**
40. A horizontal steam engine running at 120 rpm has a bore of 250 mm and a stroke of 400 mm the connecting rod is 0.6 m and mass of the reciprocating parts is 60 kg. When the crank has turned through an angle of 45° from the inner dead centre, the steam pressure on the cover end side is 550 $kN.m^2$ and that on the crank end side is 70 kN/m^2 considering the diameter of the Piston rod equal to 500 mm, determine.(i). Turning moment of the crankshaft, (ii) Thrust on the bearing, and (iii).Acceleration of the flywheel, if the power of the engine is 20 KW, mass of the flywheel 60 kg and radius of gyration 0.6m **(MAY / JUNE -2014) (16)**
41. A shaft fitted with a flywheel rotates at 250 rpm and drives a machine. The torque of machine varies in a cyclic manner over a period of 3 revolutions. The torque rises from 750 Nm to 3000 Nm uniformly during ½ revolution and remains constant for the following revolution. It then falls uniformly to 750 Nm during next ½ revolution and remain constant for one revolution, the cycle being repeated thereafter. Determine the power required to drive the machine and percentage fluctuation in speed, if the driving torque applied to the shaft is constant and the mass of the flywheel is 500 kg with radius of gyration of 600 mm. **(MAY / JUNE -2014) (16)**
42. The lengths of crank and connecting rod of a horizontal reciprocating engine are 100 mm and 500 mm respectively. The crank is rotating at 400 rpm. When the crank has turned 30° from the inner dead centre, find analytically (i) acceleration of the piston (ii) velocity of the piston (iii) angular velocity of the connecting rod and (iv) angular acceleration of the connecting rod. **(MAY / JUNE -2015) (16)**