This question paper contains 8+3 printed pages]

HPAS (Main)—2012

MECHANICAL ENGINEERING

Paper I

Time : 3 *Hours* *Maximum Marks :* 150

Note :— Attempt total *five* questions. Question No. 8 is compulsory. Use of quality control hand-book, calculator, Graph-sheet is permitted. Assume missing data, if any, suitably.

1. (*a*) A cable in a suspension bridge has a span of 100 m and dip 10 m. It carries a load of 12 kN/m of horizontal span. Find the maximum tension and the inclination of the cable at the supports. Also determine the forces transmitted to the supporting tower if the cable is :

(*i*) Passing over a smooth pulley on the top of pillar

P.T.O.

(*ii*) Clamped to a saddle with the roller support.

For each of the above cases, the anchor cable is at 30° to the horizontal. 16

(*b*) A roller of radius 10 cm rides between two horizontal bars moving in the opposite directions as shown in Fig.1.

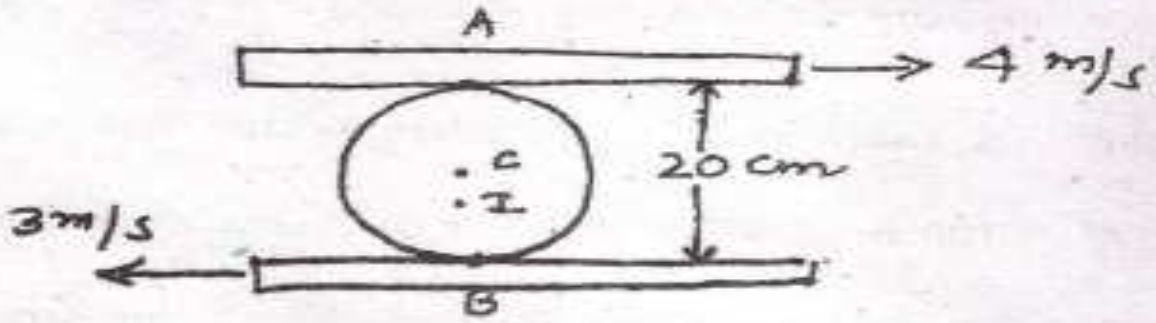

Fig.1.

Assuming no slip at the points of contacts A and B located the instantaneous centre of the roller. Where will be the instantaneous centre when both the bars are moving in the same direction ? 14

2. (*a*) In the pump mechanism shown in Fig. 2, OA = 320 mm, AC = 680 mm and OQ = 650 mm. For the given configuration, determine :

(*i*) the angular velocity of the cylinder

(*ii*) to sliding velocity of the plunger

(*iii*) the absolute velocity of the plunger

The crank OA rotates at 20 rad/s clockwise. 12

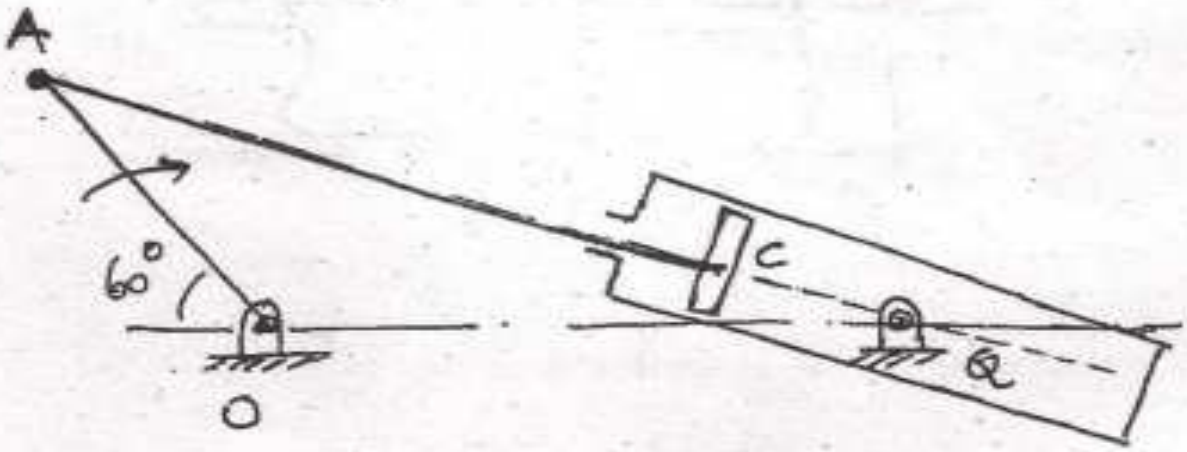

Fig.2.

P.T.O.

(b) The no. of teeth in the gear shown in Fig. 3 is as follows :

$T_S = 18,\ T_P = 24,\ T_C = 12,\ T_A = 72$

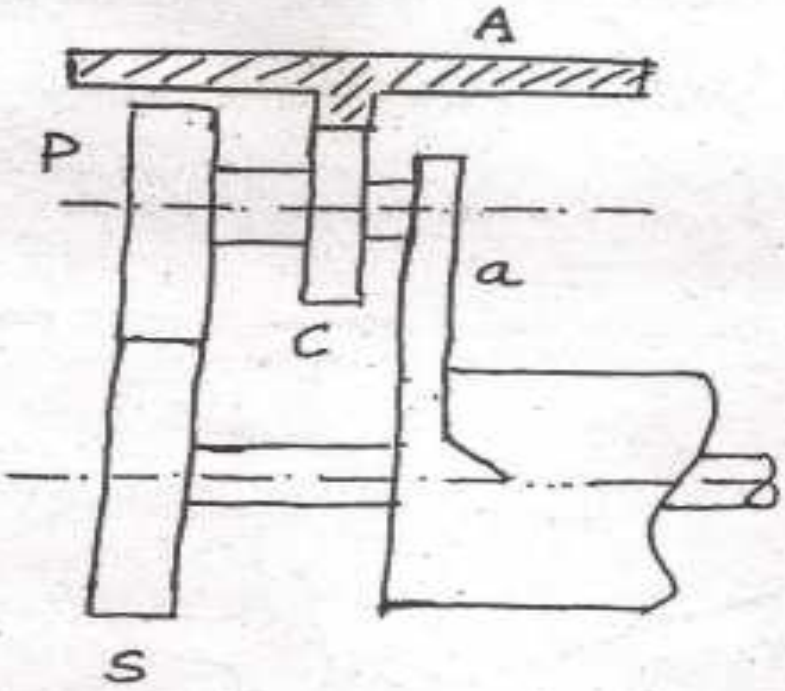

Fig.3.

'P' and 'C' form a compound gear carried by the arm 'a' and the annular gear 'A' is held stationary.

Determine the speed of the output at 'a'. Also find the holding torque required on 'A' if 5 kW is delivered to 'S' at 800 r.p.m. with an efficiency of 94%. In case the annulus 'A' rotates at 100 r.p.m. in the same direction as 'S', what will be the new speed of 'a' ? 18

3. (a) Each arm of a Porter Governor is 250 mm long. The upper and lower arms are pivoted to links of 40 mm and 50 mm respectively from the axis of rotation. Each ball has a mass of 5 kg and the sleeve mass is 50 kg. The force of friction on the sleeve of the mechanism is 40 N. Determine the range of speed of the governor for extreme radii of rotation of 125 mm and 150 mm. 15

(b) A rotor has a mass of 12 kg and is mounted midway on a 24 mm diameter horizontal shaft supported at the ends by two bearings. The bearings are 1 m apart. The shaft rotates at 2400 rpm. If the centre of the mass of the rotor is 0.11 mm away from the geometrical centre of the rotor due to certain manufacturing defect, find the amplitude of the steady state vibration and the dynamic force transmitted to the bearing. Take E = 200 GN/m^2. 15

4. (a) A plane element in a body is subjected to a normal stress of 25 MPa in +ve X-direction and counter-clockwise shear stress of 100 MPa as shown in Fig.4.

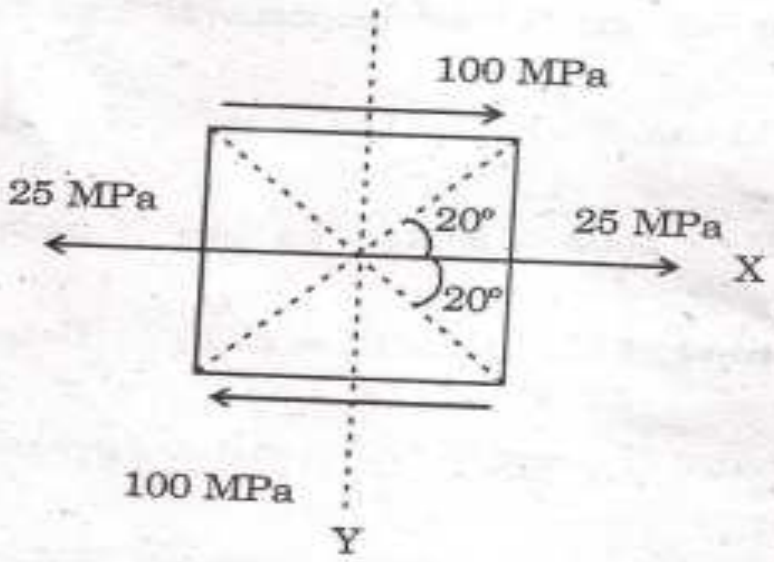

Fig.4.

Calculate the principal stress, maximum shear stress at two planes :

(i) 20° clockwise

(ii) 20° anticlockwise to X-direction, using Mohr's circle method. 18

(b) A circular bar is to withstand a bending moment of 10 kN-m and a torque of 30 kN-m. Determine the diameter of the bar if the yield stress of the material is 250 MPa and factor of safety is 2. Use maximum normal stress theory of failure. Take Poisson's ratio = 0.3. 12

5. (a) Find out the resultant force, MRR, shear strain and H.P. at the tool per cubic cm of metal removed per minute from the following data :

Depth of cut = 8 mm

Feed = 0.8 mm/rev

Cutting speed = 64 mpm

Back rake angle = 10°

Chip thickness ratio = 0.30

Shear stress of the material at zero compressive stress = 950 kg/cm^2

Assume 'K' as 0.22 in the equation :

$2\phi + \beta - \alpha = c \cot^{-1}K$ 18

(b) With neat sketch explain the following processes : 12

(i) Ultrasonic machining;

(ii) Laser beam machining.

6. (a) Establish the tool life equation and calculate the cutting speed for 5 minutes of tool life from the following data :

A tool life of 75 minutes obtained at a speed of 25 mpm at that of 10 minutes when cutting 60 mpm. 10

(b) Solve the following LPP using simplex method :

Maximize $Z = 10x_1 + 15x_2 + 20x_3$

Subject to : $2x_1 + 4x_2 + 6x_3 \leq 24$

$3x_1 + 9x_2 + 6x_3 \leq 30$

$x_1, x_2, x_3 \geq 0$ 15

(c) Explain graphical method of solving L.P. Problems. 5

7. (a) A double sampling plan is as follows : 15

(i) Select a sample of 2 from a lot of 20. If both articles inspected are good accept the lot, if both are defective reject the lot.

(ii) If 1 is good and 1 defective, take a second sample of one article, if the article in the second sample is good accept the lot, if it is defective reject the lot.

If a lof 25% defective is submitted, what is the probability of acceptance ?

(*b*) Subgroups of 5 items each are taken from a manufacturing process at regular intervals. A certain quality characteristic is measured and $\bar{X}$, R value are computed for each subgroup. After 25 subgroups $\Sigma \bar{X} = 367.50$ and $R = 9.10$. Compute the control chart limits. All points on both the charts fall within these limits. If the specification limits are 14.40 ± 0.40, what conclusions you can draw about the ability of the existing process to produce within the specifications ? Suggest possible ways in which the situation can be improved. 15

8. Write short notes on : 6×5=30

(a) Conjugate action in gearing and interference

(b) Combined bending and torsion effects

(c) Electrochemical machining process

(d) Line balancing

(e) Operating characteristics curves

(f) Damped vibration for single d.o.f.