UNIVERSITY OF LONDON

B.Sc. (ENGINEERING) EXAMINATION 1962

PART I

for Internal and External Students

(3) MECHANICS OF MACHINES

Wednesday, 20 June: 2.30 to 5.30

It may be assumed that the gravitational acceleration is equal to the standard acceleration.

Answer FIVE questions.

1. A machine is fitted with a cast-iron flywheel, of outer diameter 3 ft. The rim is of rectangular cross-section, the thickness radially being 4 in and the width in the axial direction being 7 in. Cast iron has density 0·26 lb/in^3. Calculate the moment of inertia of the flywheel about its axis, assuming that only the rim need be taken into account.

The machine operates cyclically, each cycle occupying 5 revolutions. The torque required to drive the machine is 80 lbf ft during the first revolution, zero during the second, 100 lbf ft during the third, and zero during the fourth and fifth revolutions of the cycle. The driving torque supplied to the machine is constant. The maximum speed of the machine is 100 rev/min. Assuming that rotating parts other than the flywheel have negligible inertia, find (*a*) the minimum speed, (*b*) the maximum acceleration and (*c*) the maximum deceleration, stating at which points in the cycle these occur.

2. A body A, of mass 50 lb is lifted by a rope which passes over a guide pulley B and on to a drum C, as shown in Figure 1. The inclination of the rope between the pulley and the drum is 40° to the horizontal. The guide pulley has mass 120 lb, radius of gyration 15 in, and effective radius to the centre of the rope 18 in; the friction torque at its bearings is 10 lbf ft. The corresponding figures for the drum are 200 lb, 8 in, 10 in, 15 lbf ft. It may be assumed that no slipping occurs between the rope and the guide pulley, and that the mass of the rope is negligible.

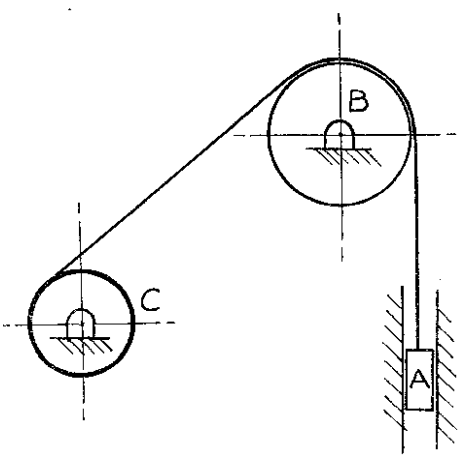

FIGURE 1

(*a*) Find the power to be supplied to the drum when A is being lifted with velocity 10 ft/s and acceleration 3 ft/s^2.

(*b*) Find the least value which the coefficient of friction between the rope and the guide pulley may have to ensure that there is no slip under these conditions.

Turn over

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3. Figure 2 shows a mechanism in which links AP and BQ rotate about fixed axes P and Q, perpendicular to the plane of the diagram, whilst rod BC slides through a trunnion R which can rotate about a fixed axis. When the angle APQ = 90° as shown, PA has an anticlockwise angular velocity of 20 rad/s and an anticlockwise angular acceleration of 200 rad/s^2. Find:

(*a*) the velocity of C;
(*b*) the angular velocity of QB, stating direction;
(*c*) the angular acceleration of QB, stating direction.

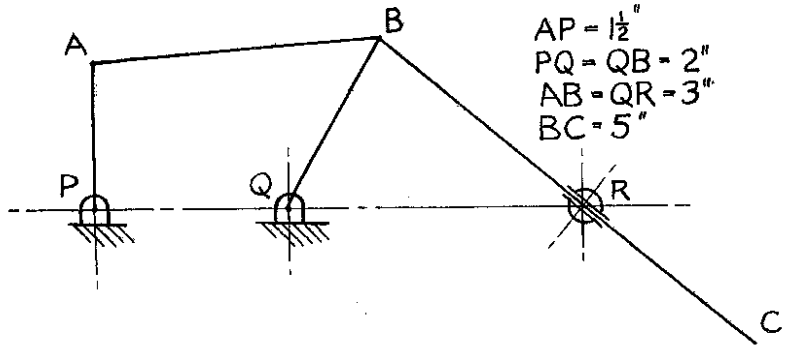

FIGURE 2

4. Two bodies A and B move in the same straight horizontal line, any collision between them being cushioned by a spring attached to one of them. The mass of A is 18 lb and that of B is 10 lb. Immediately prior to such a collision, A is moving to the right with velocity 8 ft/s and B to the left with velocity 2 ft/s. Assuming no loss of energy and that friction may be ignored, find the velocities and directions of motion of A and B after the collision.

If the maximum force between A and B at any time during the collision is not to exceed 80 lbf, find the maximum allowable spring stiffness.

5. A shaft carries four eccentric rotors A, B, C and D in that order. AB = 14 in, BC = 18 in, CD = 22 in. The respective masses and eccentricities are A, 6 lb, ½ in; B, 4½ lb, ¾ in; C, 5 lb, 1 in; D, 8 lb, *R*. In the end view the radial lines joining the centre O of the shaft to the centres of mass of the rotors make the following angles, measured clockwise from OA, AOB = 80°, AOC = 190°, AOD = θ.

Find *R* and θ so that the shaft may be in static balance and for this arrangement find the rocking couple when the shaft rotates at 100 rev/min.

6. The suspension unit for the wheel of a vehicle is shown in Figure 3. AB and CD are rigid links, respectively 15 in and 12 in between centres, which are pinned to the wheel support at B and C and to the frame of the vehicle at A and D. A suspension spring is attached to pin D and to a pin E on AB where BE = 7 in.

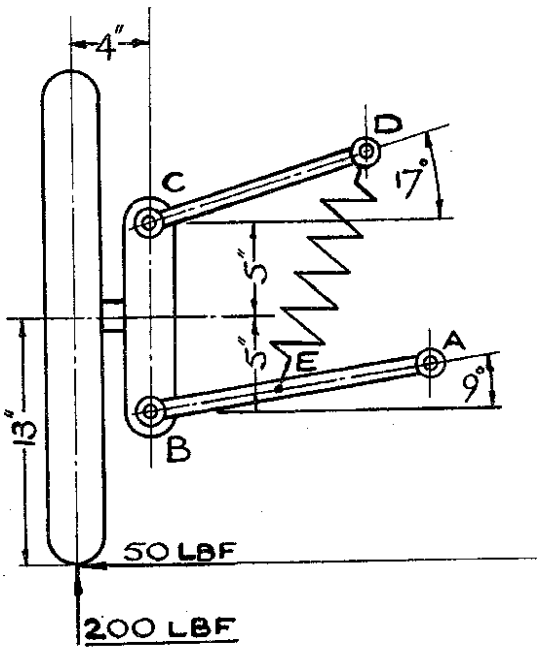

FIGURE 3

If the suspension unit is in the given configuration while the wheel is being subjected to loads of 200 lbf and 50 lbf as shown, determine the forces on the pins at A, B, C, D and E and the maximum bending moment in link AB.

The wheel with its stub axle and support may be regarded as being one rigid body and the weights of all components are to be neglected.

A graphical method is suggested.

7. A steel wire stay is tightened by means of a turnbuckle. The stay is 20 ft long and has a diameter of $\frac{3}{8}$ in. E for steel is 30×10^6 lbf/in^2. The turnbuckle has right and left hand single-start square threads with an external diameter of 1 in and a pitch of $\frac{1}{4}$ in. The coefficient of friction is 0·15.

Determine the work to be done on the turnbuckle in order to increase the tension in the stay (*a*) from zero to 400 lbf, (*b*) from 600 lbf to 1000 lbf.

8. A cam consists of a circular disc, 3 in diameter with geometric centre C, which rotates in a vertical plane about a horizontal axis O where OC = $\frac{1}{2}$ in. The cam operates a follower of mass 4 lb which has a horizontal face in contact with the cam and which moves along a vertical line above the cam. The cam rotates at a uniform speed of 200 rev/min and the camshaft is balanced. The coefficient of friction between the cam and the follower is 0·1 and friction elsewhere may be neglected.

When the cam has turned through angle θ from the position in which C is vertically below O, derive expressions for

(*a*) the displacement of the follower from its lowest position,
(*b*) the velocity of sliding between the cam and the follower,
and (*c*) the driving torque which is required on the camshaft.

Turn over

9. The overdrive for a vehicle consists of the epicyclic gear train shown in Figure 4, with compound planets BC. B has 15 teeth and meshes with the annulus A which has 60 teeth. C has 20 teeth and meshes with the sun wheel D which is fixed. All teeth have the same diametral pitch. The annulus is keyed to the propeller shaft Y which rotates at 4·55 times the speed of the road wheels, these having a rolling diameter of 26 in. The spider, which carries the pins upon which the planets revolve, is driven directly from the main gear box by shaft X, this shaft being free to rotate relatively to wheel D.

When the vehicle is travelling at 120 mile/h and the engine is developing 180 hp determine

(*a*) the speed of the shaft X,

and (*b*) the fixing torque on the sun wheel D.

Assume 100% efficiency throughout.

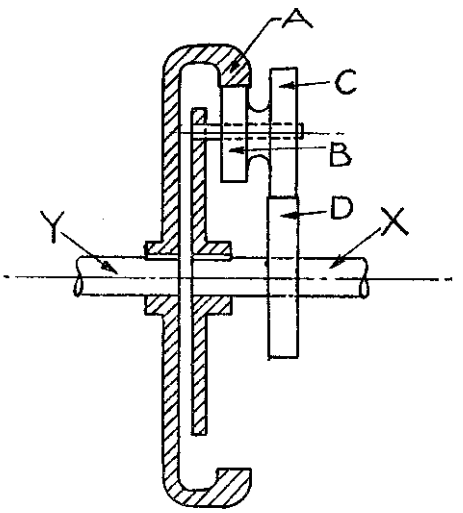

FIGURE 4.

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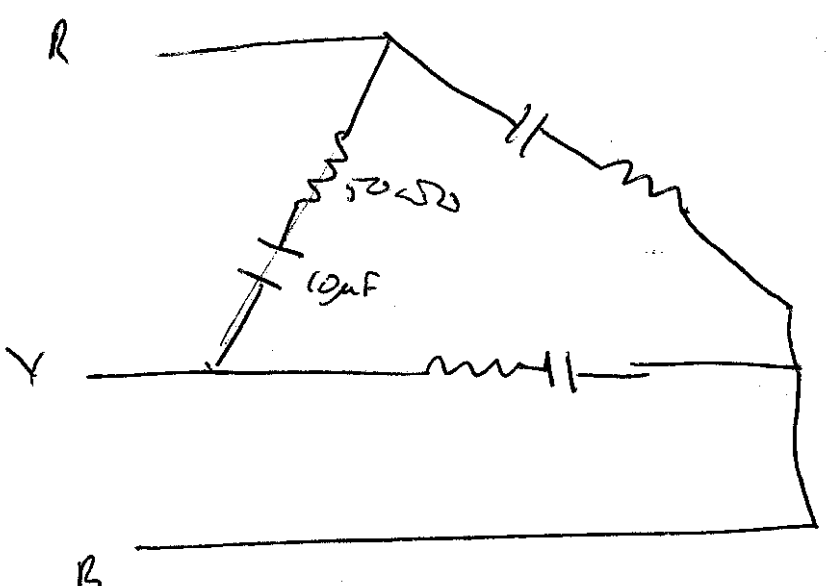

$V = \frac{2}{3} I$

Delta.

$I_L = \sqrt{3} I_P$

I