APPLIED MECHANICS

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

1. A 6 m long ladder with uniform cross-section has a mass of 30 kg. The base of the ladder rests on level ground and it is leant against a wall such that 2 m of its length is above the point contact with the wall.

   The ladder forms an angle of 30° with the vertical face of the wall and the coefficient of friction between all contact surfaces is 0.2.

   Calculate the highest point to which a 70 kg person can ascend without the ladder slipping. (16)

2. An 80 kg solid homogenous 1 m diameter cylinder is suspended vertically by a cable wrapped around its circumference that is secured to a horizontal surface at its free end as shown in Fig Q2.

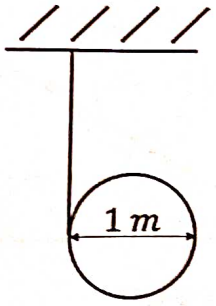

Fig Q2

The system is released from rest and the cylinder freely drops vertically a distance of 2 m.

Calculate EACH of the following:

(a) the linear velocity of the mass centre; (12)

(b) the angular impulse imparted to the cylinder. (4)

3. A solid drive shaft is upgraded to a hollow equivalent. The hollow shaft is fabricated from higher-grade steel so that the safe working stress is 20% greater and the external diameter is the same as the original solid shaft it is replacing.

Calculate the percentage saving in weight. (16)

4. A projectile is fired vertically upwards with an initial velocity of 180 m/s. The effect of air resistance is a constant force equal to one-ninth of the gravitational force experienced by the projectile.

Calculate EACH of the following:

(a) the maximum height attained by the projectile; (4)

(b) the difference in time of flight between launch to maximum height and from maximum height to impact. (12)

5. A grooved wheel is pulled up a rail inclined 30° above the horizontal by a rope running on a frictionless pulley that is attached to block A. The wheel rolls and block A has a mass of 80 kg as shown in Fig Q5.

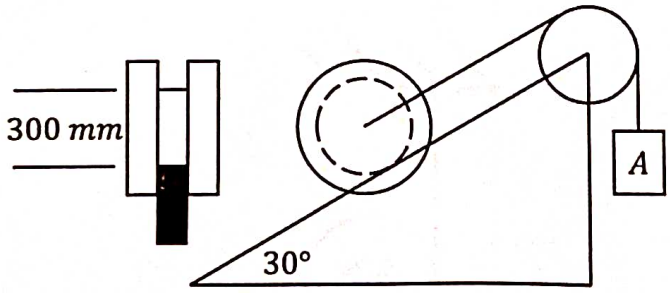

Fig Q5

The wheel has a mass of 120 kg and a 275 mm radius of gyration.

Calculate the time taken for the wheel to uniformly accelerate to a velocity of 2 m/s from rest. (16)

6. An 18 mm diameter steel cable running over a pulley is used to vertically lower a mass of 2.3 tonnes at a constant velocity of 0.25 m/s. The pulley suddenly jams when the length of the cable is 10 m.

Calculate the extension of the cable due to the sudden stop. (16)

Note: Modulus of Elasticity for steel = 208 GN/m^3

7. A single cylinder 4 stroke engine develops 60 kW at an average speed of 240 rpm. The energy fluctuation per cycle is 3.5% of the total. Speed variation is restricted to $\pm$ 2% by a flywheel with a radius of gyration of 0.45 m.

Calculate the mass of the flywheel. (16)

8. A drive pinion and gear wheel system provide a speed reduction ratio of 3 to 1. The 45 kg pinion has a 150 mm radius of gyration whilst the 420 kg gear wheel has a 440 mm radius of gyration.

Under no load, the pinion attains its maximum rotational speed of 900 rpm in 150 revolutions from rest.

Calculate EACH of the following:

(a) the minimum input torque required at the pinion; (12)

(b) total kinetic energy of the system at maximum speed. (4)

9. A screw jack being used to raise a mass of 180 kg is driven by a single-start square thread with a pitch of 6 mm and a mean diameter of 80 mm. The mean diameter of the bearing surface beneath the loading cap is 250 mm and the radial length of the lifting lever from the polar axis of the square thread is 450 mm.

The coefficients of friction at the thread and the bearing surface are 0.12 and 0.28 respectively.

Calculate the difference between the force required to raise the mass and the force required to lower the mass. (16)