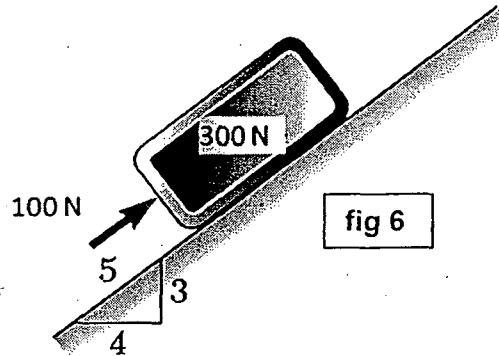
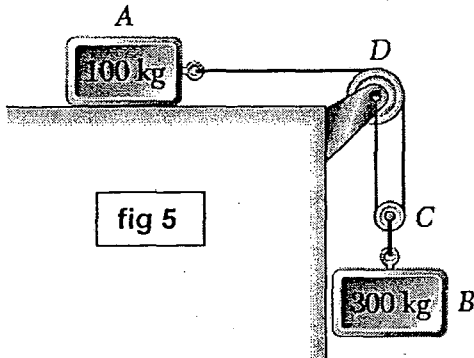


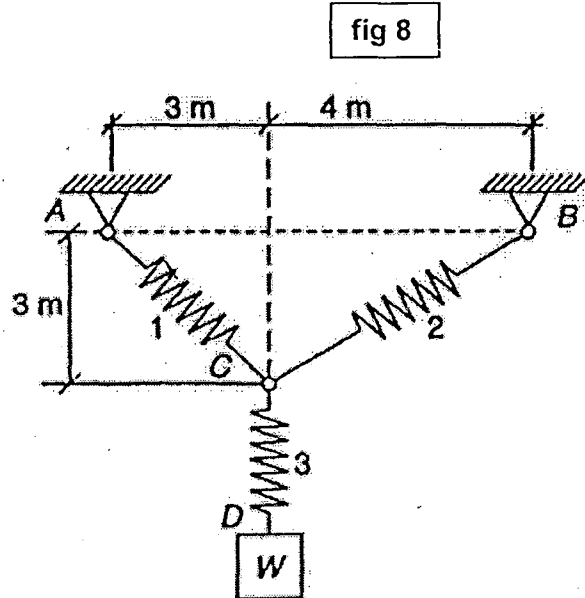
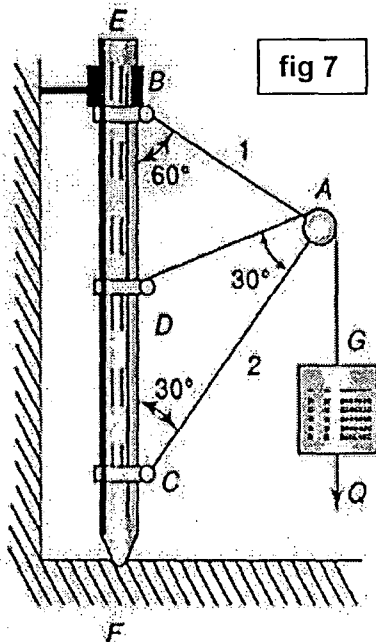
5. State the parallel axis theorem for finding moment of inertia of an area.
6. What is radius of gyration of an area?
7. Determine the smallest radius that should be used for a highway if the normal component of the acceleration of a car traveling at 54 km/h is not to exceed 1 m/s^2 .
8. The two blocks shown start from rest (fig. 5). The horizontal plane and the pulley are frictionless, and the pulley is assumed to be of negligible mass. If the acceleration of block A is 8.4 m/s^2 , what is the acceleration of block B?



9. A 100 N force acts on a 300 N block placed on an inclined plane (fig. 6). The coefficients of friction between the block and the plane are $\mu_s = 0.25$ and $\mu_k = 0.2$. Determine the maximum friction force which could be developed between the block and the plane.
10. Why coefficient of kinetic friction is less than that of static friction?

Part – B (5 x 16 = 80 marks)

11. (i) A pulley A is supported by two bars AB and AC which are hinged at points B and C to a vertical mast EF (Fig.7). Over the pulley hangs a flexible cable DG which is fastened to the mast at D and carries at the other end G a load $Q = 20 \text{ kN}$. Neglecting friction in the pulley, determine the forces produced in the bars AB and AC. The angles between the various members are shown in figure. (8 marks)



(ii) Determine the stretch in each spring for equilibrium of the weight $W = 40 \text{ N}$ block as shown in Fig. 8. The springs are in equilibrium position. The stiffness of each spring is given as: $k_1 = 40 \text{ N/m}$, $k_2 = 50 \text{ N/m}$ and $k_3 = 60 \text{ N/m}$. (8 marks)

12. a) (i) A 300 N force is applied to the handle of the winch as shown (fig. 9). The force lies in a plane which is parallel to the y-z plane and is perpendicular to line AB of the handle. Determine the moments of this force about point O and about the x-axis. (6 marks)

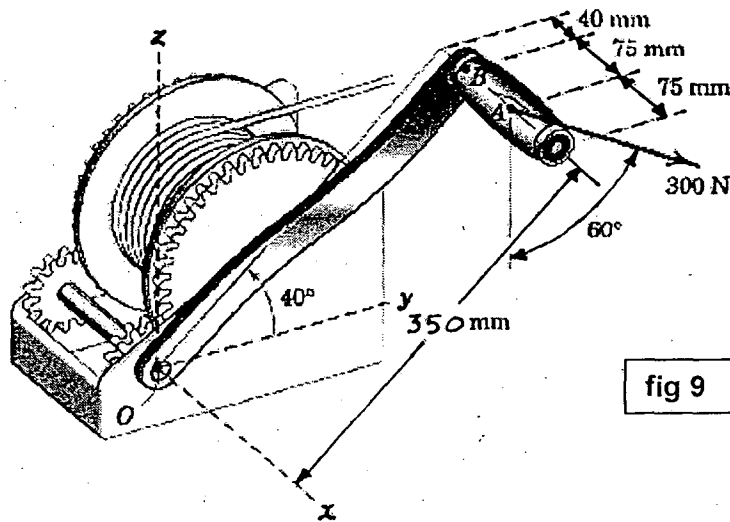


fig 9

(ii) A space shuttle orbiter is subjected to thrusts from five of the engines of its reaction control system (fig. 10). Four of the thrusts are shown in the figure; the fifth is an 850 N upward thrust at the right rear, symmetric to the 850 N thrust shown on the left rear. Compute the moment of these forces about point G and show that the forces have the same moments about all the points. (10 marks)

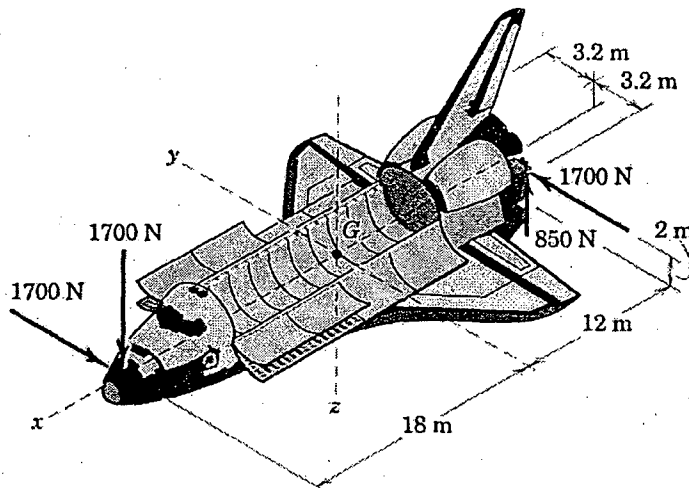


fig 10

[OR]

b) (i) Determine the magnitude of a horizontal force applied at the center C of a roller of weight $Q = 4450 \text{ N}$ and radius $r = 381 \text{ mm}$ which will be necessary to pull it over a 76.2 mm curb (fig. 11). (8 marks)

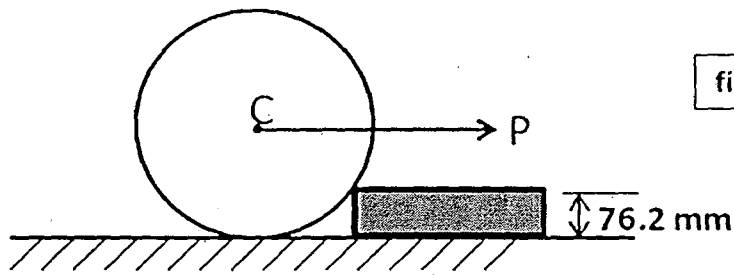


fig 11

(ii) A roller of radius $r = 304.8$ mm and weight = 2225 N is to be pulled over a curb of height $h = 152.4$ mm by a horizontal force P applied to the end of a string wound around the circumference of the roller (fig. 12). Find the magnitude of P required to start the roller over the curb. (8 marks)

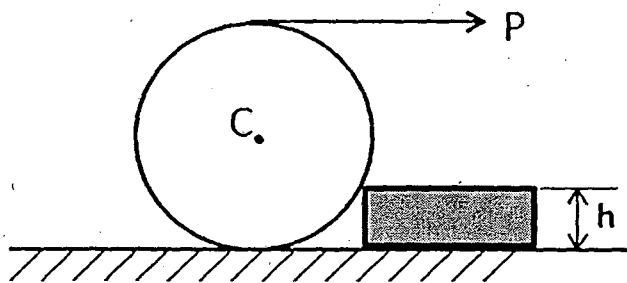


fig 12

13. a) (i) Determine the coordinates of the centroid of the shaded area (fig. 13). (8 marks)

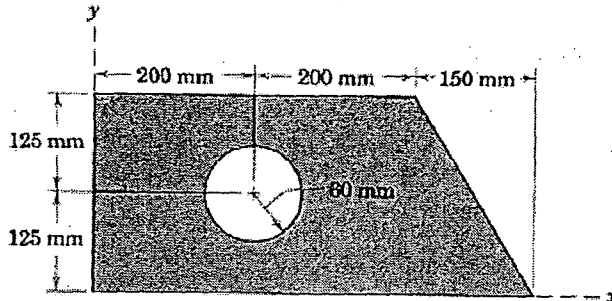


fig 13

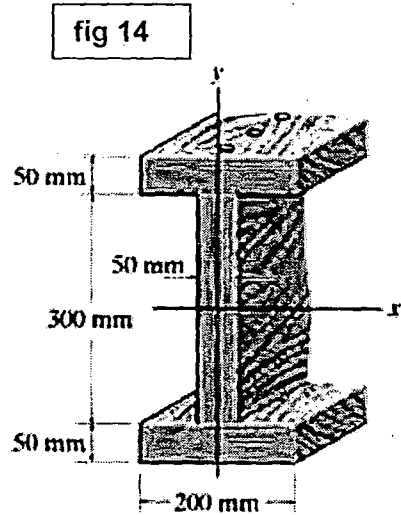
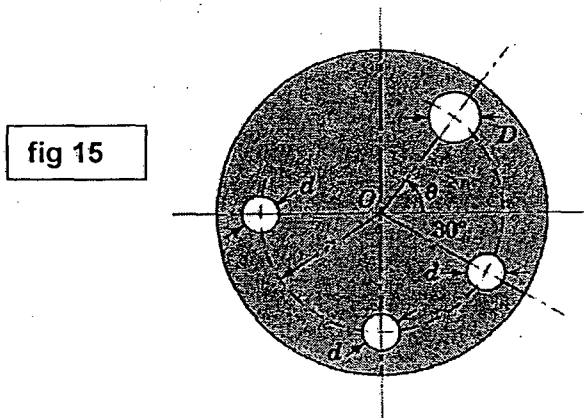


fig 14

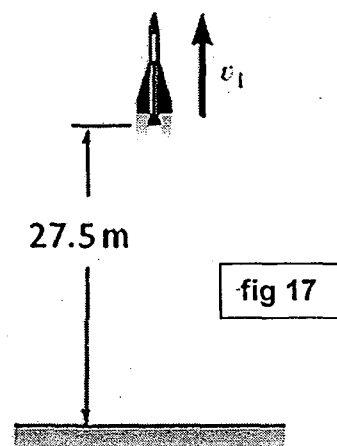
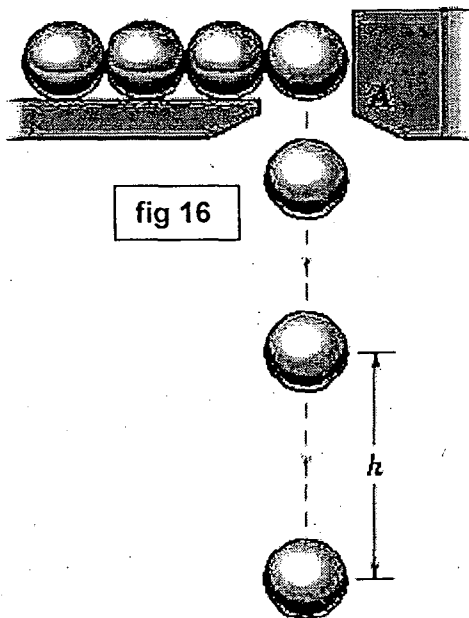
(ii) Determine the moment of inertia of the cross-sectional area (I section) of the channel with respect to the y axis (fig. 14). (8 marks)

[OR]

- b) The circular disk shown in Fig. 15 rotates about an axis through its center O and has three holes of diameter d positioned as shown. A fourth hole is to be drilled at the same radius r so that the disk will be in balance (center of mass at O). Determine the required diameter D of the new hole (in terms of d) and its angular position.



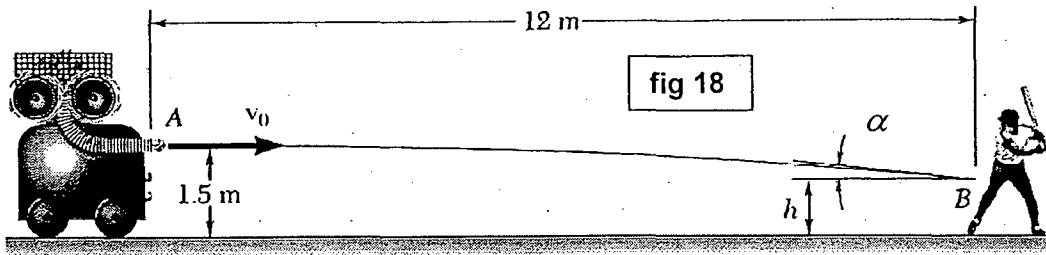
14. a) (i) Small steel balls fall from rest through the opening at A at the steady rate of two per second (fig. 16). Find the vertical separation h of two consecutive balls when the lower one has dropped 3 metres. Neglect air resistance. (8 marks)



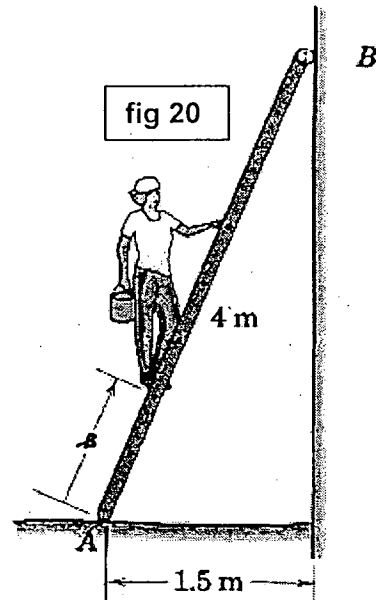
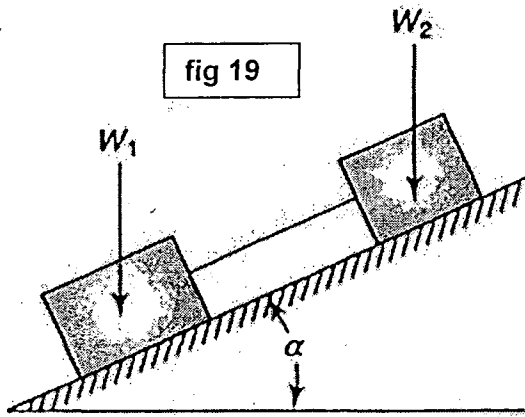
- (ii) A group of students launches a model rocket in the vertical direction (fig. 17). Based on tracking data, they determine that the altitude of the rocket was 27.5 m at the end of the powered portion of the flight and that the rocket landed 16 s later. Knowing that the descent parachute failed to deploy so that the rocket fell freely to the ground after reaching its maximum altitude and assuming that $g = 9.8 \text{ m/s}^2$, determine (a) the speed v_1 of the rocket at the end of powered flight, (b) the maximum altitude reached by the rocket. (8 marks)

[OR]

- b) A baseball pitching machine (fig. 18) "throws" baseballs with a horizontal velocity v_0 . Knowing that height h varies between 0.8 m and 1 m, determine (a) the range of values of v_0 , (b) the values of α corresponding to $h = 0.8 \text{ m}$ and $h = 1 \text{ m}$.



15. a) Two blocks of weight W_1 and W_2 rest on a rough inclined plane (fig. 19) and are connected by a short piece of string as shown in Fig. If the coefficients of friction are $\mu_1 = 0.2$ and $\mu_2 = 0.3$, respectively, find the angle of inclination of the plane for which sliding will impend. Given: $W_1 = W_2 = 22.25\text{N}$.



[OR]

- b) (i) Determine the distance s to which the 90 kg painter can climb without causing the 4-m ladder to slip at its lower end A (fig. 20). The top of the 15-kg ladder has a small roller, and at the ground the coefficient of static friction is 0.25. The mass center of the painter is directly above her feet. (8 marks)

- (ii) A 120 kg block (fig. 21) is supported by a rope that is wrapped $1\frac{1}{2}$ times around a horizontal rod. Knowing that the coefficient of static friction between the rope and the rod is 0.15, determine the range of values of P for which equilibrium is maintained. (8 marks)

