7 **(a)** Two blocks, P and Q, of masses 0.50 kg and 1.00 kg respectively, are connected by a string that passes over a pulley as shown in Fig. 7.1. The spring constant is 200 N m^{-1}.

The pulley is light and frictionless, and the string is inextensible. The system is released from rest.

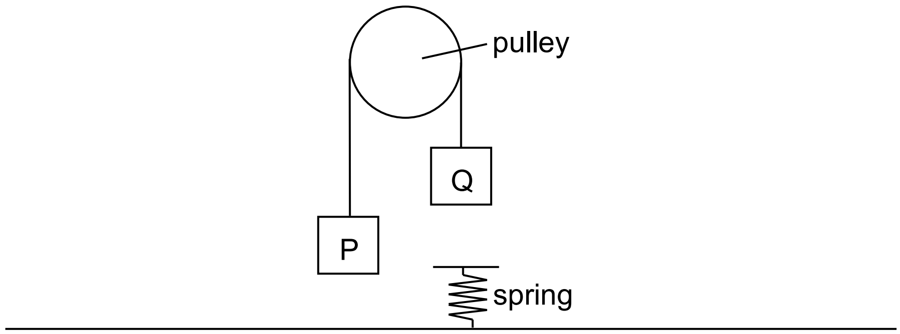

Fig. 7.1

Block Q falls vertically before it strikes a spring that is firmly attached to the floor.

(i) Determine the tension in the string just before block Q strikes the spring.

tension in the string = …………………..……. N [3]

(ii) The acceleration of Block Q decreases after it touches the spring. Block Q comes to a permanent stop after some time and the spring is observed to be compressed.

Calculate the compression of the spring, x.

compression of spring, x = ……………………..…… m [2]

(b) A bullet of mass 5.0 g is fired from a gun into a block of mass 0.500 kg, which is suspended by thin threads from fixed points. The bullet remains in the block, which swings upwards as to a maximum height of h as shown in Fig. 7.2.

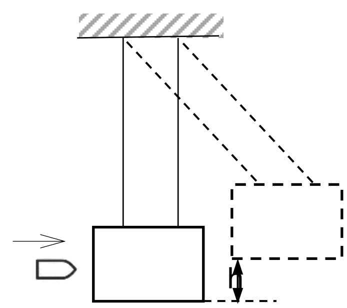

Fig. 7.2

(i) If the velocity of the bullet just before it strikes the block is 100 m s^{-1}, determine the maximum height h.

maximum height = ……………………..…… m [2]

(ii) State the type of collision between the bullet and the block.

.... [1]

(c) Fig 7.3 below shows a ride that involves a train being launched by a mechanism that accelerates it to 89 km h^{-1} in 4.5 seconds. The train will then negotiate a 23.0 m diameter loop before ascending the open-end 45.0 m tall front track. The train then falls backwards under its own weight, going through the loop a second time, ascending the back vertical track and returning to its starting position at the station, brought to a halt through brakes in the station.

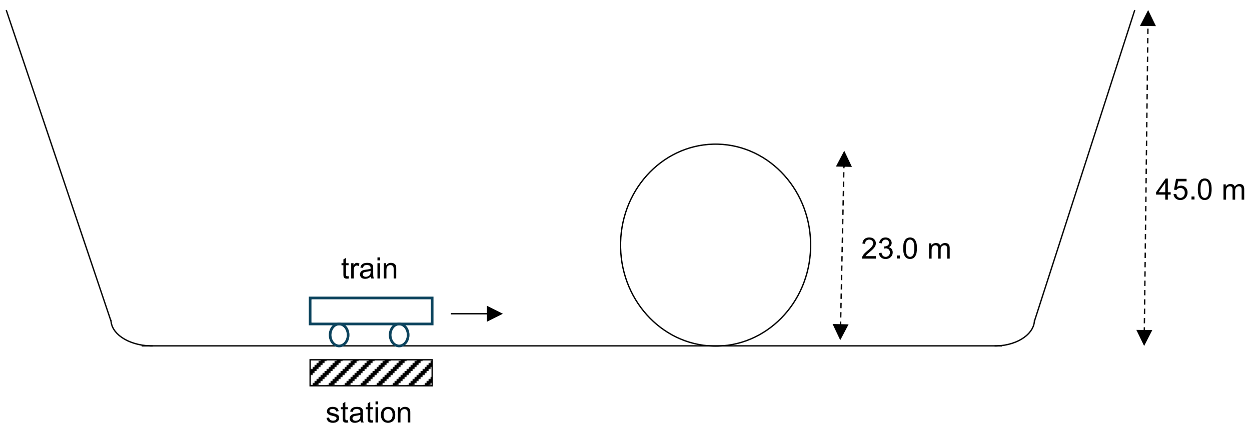

Fig. 7.3

In a typical operation, 28 riders in a single train with 7 cars have a combined mass of 6500 kg. Assume that the track is smooth.

(i) Determine the average power required by the mechanism to bring the train to 89 km h^{-1} in 4.5 s.

average power = ... W [1]

(ii) Show that the train will not travel beyond the open-end part of the track after emerging from the loop.

[1]

(iii) Each rider is to be restrained by a lap bar. Should the lap bar's locking mechanism fail and unlock itself as the train negotiates the loop, determine if the rider will fall off the train. Show all calculations clearly.

…………………………………………………………………………………………….....

…………………………………………………………………………………………….. [3]

(d) A boom can be used to assist a person to move heavy loads. A typical arrangement is shown below.

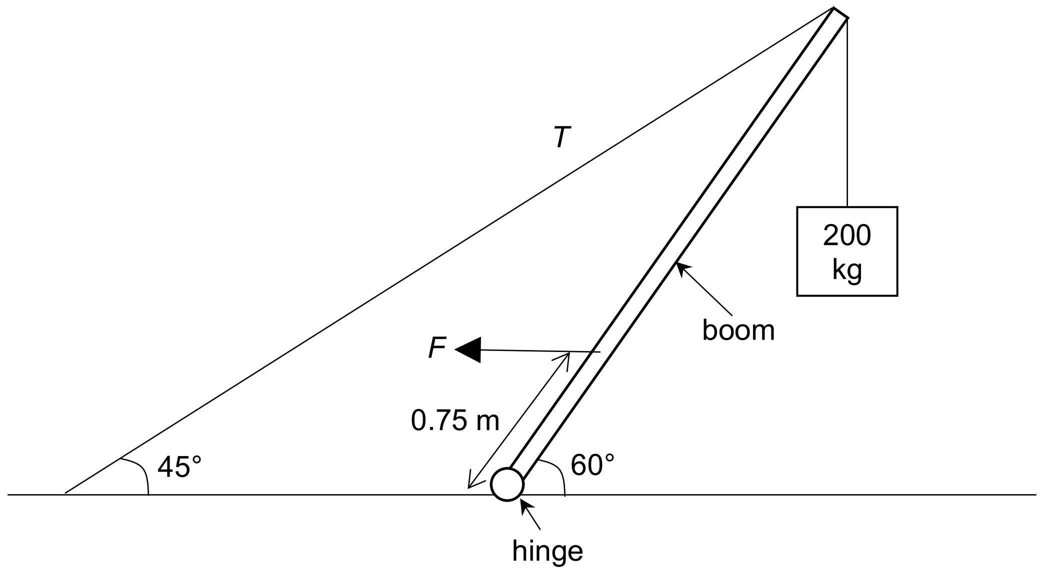

Fig. 7.4

The boom is angled at 60° to the horizontal, and a steel cable is attached to the top of the boom and the floor such that the cable makes an angle of 45° to the horizontal, as shown. The uniform boom has a mass of 45 kg and length 3 m.

A human operator exerts a force F = 120 N horizontally at a distance 0.75 m away from the hinge as measured along the boom. The system is in equilibrium.

(i) State the conditions for a body to be in static equilibrium.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………... [2]

(ii) Show that the tension *T* in the cable connecting from the top of the boom to the floor is 4.1 kN.

[2]

(iii) Determine the magnitude and direction of the force exerted by the hinge on the boom.

magnitude of force = ………………………….. N

direction of the force
= ……………..……………………………………………… [3]