Topic X4 Mechanics (Pre-TT B) [32]

Based on chapters 21-22

1.

In this question use $g = 10$ m s^{-2}, giving your final answers to an appropriate degree of accuracy.

A man of mass 80 kg is travelling in a lift.

The lift is rising vertically.

The lift decelerates at a rate of 1.5 m s^{-2}

Find the magnitude of the force exerted on the man by the lift.

[3 marks]

(Total 3 marks)

2.

The three forces $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$ are acting on a particle.

$$\mathbf{F}_1 = (25\mathbf{i} + 12\mathbf{j})\text{ N}$$
$$\mathbf{F}_2 = (-7\mathbf{i} + 5\mathbf{j})\text{ N}$$
$$\mathbf{F}_3 = (15\mathbf{i} - 28\mathbf{j})\text{ N}$$

The unit vectors **i** and **j** are horizontal and vertical respectively.

The resultant of these three forces is **F** newtons.

(a) (i) Find the magnitude of **F**, giving your answer to three significant figures.

[2 marks]

(a) (ii) Find the acute angle that **F** makes with the horizontal, giving your answer to the nearest 0.1°

[2 marks]

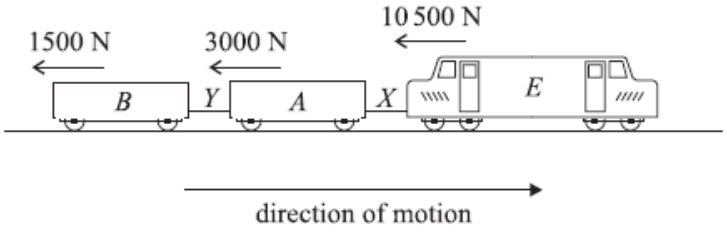
(b) The fourth force, $\mathbf{F}_4$, is applied to the particle so that the four forces are in equilibrium.

Find $\mathbf{F}_4$, giving your answer in terms of **i** and **j**.

[1 mark]

(Total 5 marks)

3.



A train of total mass 80 000 kg consists of an engine E and two trucks A and B. The engine E and truck A are connected by a rigid coupling X, and trucks A and B are connected by another rigid coupling Y. The couplings are light and horizontal. The train is moving along a straight horizontal track. The resistances to motion acting on E, A and B are 10 500 N, 3000 N and 1500 N respectively (see diagram).

(i) By modelling the whole train as a single particle, show that it is decelerating when the driving force of the engine is less than 15 000 N. [2]

(ii) Show that, when the magnitude of the driving force is 35 000 N, the acceleration of the train is $0.25\ \text{m s}^{-2}$. [2]

(iii) Hence find the mass of E, given that the tension in the coupling X is 8500 N when the magnitude of the driving force is 35 000 N. [3]

The driving force is replaced by a braking force of magnitude 15 000 N acting on the engine. The force exerted by the coupling Y is zero.

(iv) Find the mass of B. [5]

(v) Show that the coupling X exerts a forward force of magnitude 1500 N on the engine. [2]

(Total 14 marks)

4.

Particles P and Q, of masses 0.45 kg and m kg respectively, are attached to the ends of a light inextensible string which passes over a small smooth pulley. The particles are released from rest with the string taut and both particles 0.36 m above a horizontal surface. Q descends with acceleration $0.98\ \text{m s}^{-2}$. When Q strikes the surface, it remains at rest.

(i) Calculate the tension in the string while both particles are in motion. [2]

(ii) Find the value of m. [3]

(iii) Calculate the speed at which Q strikes the surface. [2]

(iv) Calculate the greatest height of P above the surface. (You may assume that P does not reach the pulley.) [3]

(Total 10 marks)