Forces and Equilibrium 1

1.

A box of mass 5 kg is at rest on a rough horizontal floor.

(i) Find the value of the normal reaction of the floor on the box. [1]

The box remains at rest on the floor when a force of 10 N is applied to it at an angle of 40° to the upward vertical, as shown in Fig. 3.

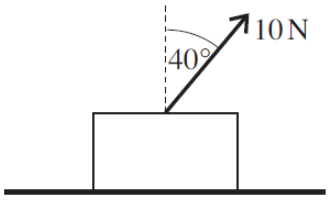


Fig. 3

(ii) Draw a diagram showing all the forces acting on the box. [2]

(iii) Calculate the new value of the normal reaction of the floor on the box and also the frictional force. [4]

2.

Fig. 1 shows four forces in equilibrium.

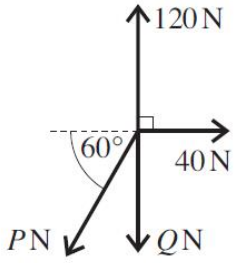


Fig. 1

(i) Find the value of P. [3]

(ii) Hence find the value of Q. [2]

3.

A block of weight 100 N is on a rough plane that is inclined at 35° to the horizontal. The block is in equilibrium with a horizontal force of 40 N acting on it, as shown in Fig. 5.

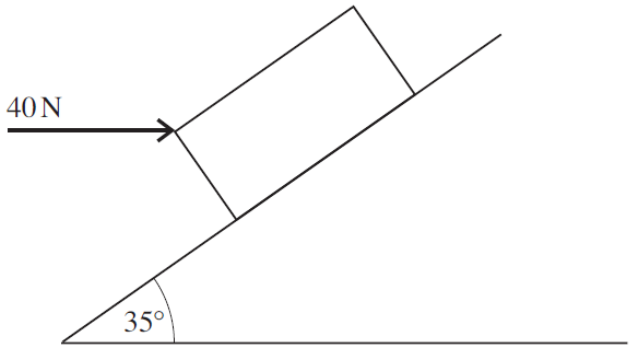


Fig. 5

Calculate the frictional force acting on the block. [4]

4.

An explorer is trying to pull a loaded sledge of total mass 100 kg along horizontal ground using a light rope. The only resistance to motion of the sledge is from friction between it and the ground.

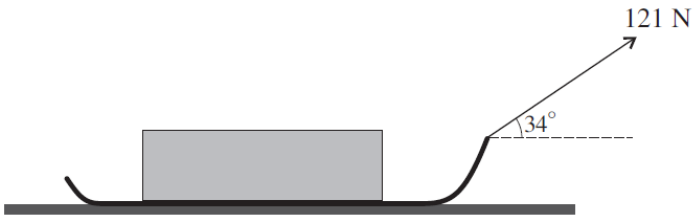


Fig. 7

Initially she pulls with a force of 121 N on the rope inclined at 34° to the horizontal, as shown in Fig. 7, but the sledge does not move.

(i) Draw a diagram showing all the forces acting on the sledge.

Show that the frictional force between the ground and the sledge is 100 N, correct to 3 significant figures.

Calculate the normal reaction of the ground on the sledge. **[7]**

5.

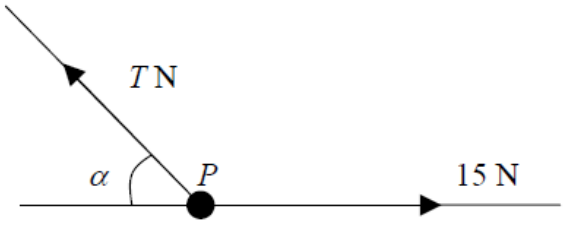


Fig. 2

A particle P of mass 2 kg is held in equilibrium under gravity by two light inextensible strings. One string is horizontal and the other is inclined at an angle α to the horizontal, as shown in Fig. 2. The tension in the horizontal string is 15 N. The tension in the other string is T newtons.

(a) Find the size of the angle α. **(6 marks)**

(b) Find the value of T. **(2 marks)**

6.

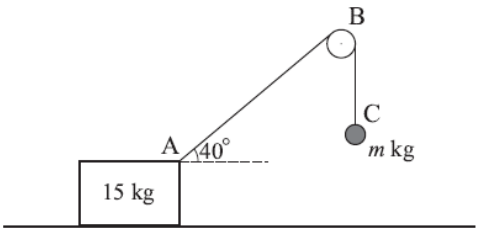


Fig. 3

Fig. 3 shows a block of mass 15 kg on a rough, horizontal plane. A light string is fixed to the block at A, passes over a smooth, fixed pulley B and is attached at C to a sphere. The section of the string between the block and the pulley is inclined at 40° to the horizontal and the section between the pulley and the sphere is vertical.

The system is in equilibrium and the tension in the string is 58.8 N.

(i) The sphere has a mass of m kg. Calculate the value of m. [2]

(ii) Calculate the frictional force acting on the block. [3]

(iii) Calculate the normal reaction of the plane on the block. [3]

7.

An empty open box of mass 4 kg is on a plane that is inclined at 25° to the horizontal.

In one model the plane is taken to be smooth.

The box is held in equilibrium by a string with tension T N parallel to the plane, as shown in Fig. 6.1.

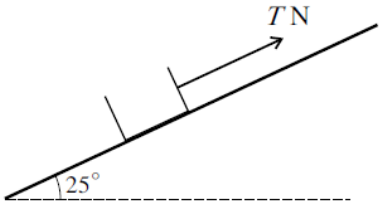


Fig. 6.1

(i) Calculate T. **[2]**

A rock of mass m kg is now put in the box. The system is in equilibrium when the tension in the string, still parallel to the plane, is 50 N.

(ii) Find m. **[3]**

In a refined model the plane is rough.

The empty box, of mass 4 kg, is in equilibrium when a frictional force of 20 N acts down the plane and the string has a tension of P N inclined at 15° to the plane, as shown in Fig. 6.2.

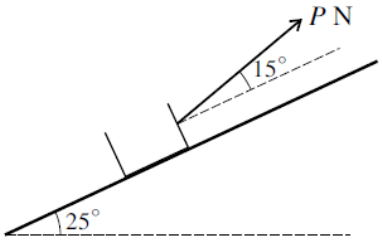


Fig. 6.2

(iii) Draw a diagram showing all the forces acting on the box. **[2]**

(iv) Calculate P. **[5]**

(v) Calculate the normal reaction of the plane on the box. **[4]**

8.

A box of mass 2.5 kg is on a smooth horizontal table, as shown in Fig. 4. A light string AB is attached to the table at A and the box at B. AB is at an angle of 50° to the vertical. Another light string is attached to the box at C; this string is inclined at 15° above the horizontal and the tension in it is 20 N. The box is in equilibrium.

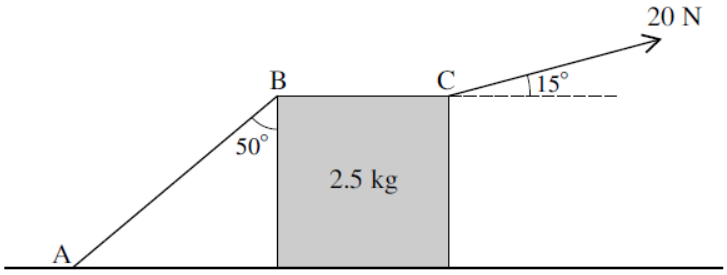


Fig. 4

(i) Calculate the horizontal component of the force exerted on the box by the string at C. **[1]**

(ii) Calculate the tension in the string AB. **[2]**

(iii) Calculate the normal reaction of the table on the box. **[4]**

The string at C is replaced by one inclined at 15° below the horizontal with the same tension of 20 N.

(iv) Explain why this has no effect on the tension in string AB. **[1]**

9.

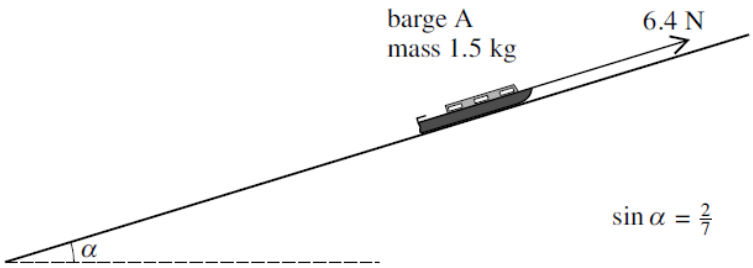


Fig. 6.1

Fig. 6.1 shows a toy barge A of mass 1.5 kg on a rough plane. The plane is at an angle α to the horizontal where $\sin\alpha = \frac{2}{7}$.

(i) Show that the component of the weight of the barge down the slope is 4.2 N. **[2]**

The barge is held in equilibrium by a force of 6.4 N acting up and parallel to the plane.

(ii) Determine the frictional force on the barge and state whether it acts up or down the plane. **[2]**

10.

Fig. 2 shows a sack of rice of weight 250 N hanging in equilibrium supported by a light rope AB. End A of the rope is attached to the sack. The rope passes over a small smooth fixed pulley.

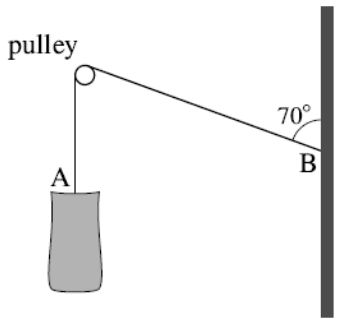


Fig. 2

Initially, end B of the rope is attached to a vertical wall as shown in Fig. 2.

(i) Calculate the horizontal and the vertical forces acting on the wall due to the rope. **[3]**

End B of the rope is now detached from the wall and attached instead to the top of the sack. The sack is in equilibrium with both sections of the rope vertical.

(ii) Calculate the tension in the rope. **[1]**

11.

Fig. 4 shows a block of mass 15 kg on a smooth plane inclined at 20° to the horizontal. The block is held in equilibrium by a horizontal force of magnitude P N.

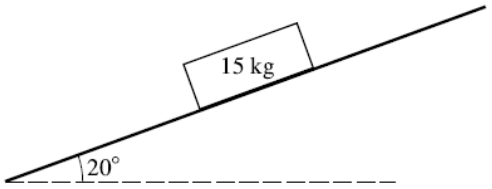


Fig. 4

(i) Show all the forces acting on the block. **[2]**

(ii) Calculate P. **[3]**

12.

Fig. 2 shows a small object, P, of weight 20 N, suspended by two light strings. The strings are tied to points A and B on a sloping ceiling which is at an angle of 60^{o} to the upward vertical. The string AP is at 60^{o} to the downward vertical and the string BP makes an angle of 30^{o} with the ceiling.

The object is in equilibrium.

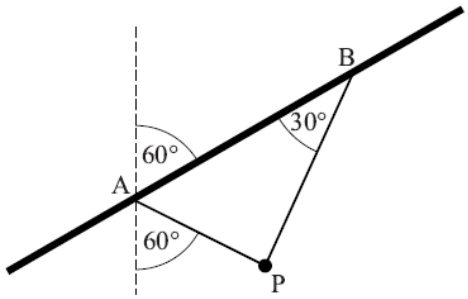


Fig. 2

(i) Show that $\angle APB = 90°$. **[1]**

(ii) Calculate the tensions in the two strings.

[4]