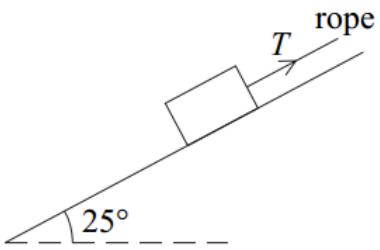
Mechanics 1: Friction

Past Paper Questions
2006 - 2013

Name:

January 2006

8 A rough slope is inclined at an angle of 25° to the horizontal. A box of weight 80 newtons is on the slope. A rope is attached to the box and is parallel to the slope. The tension in the rope is of magnitude T newtons. The diagram shows the slope, the box and the rope.



(a) The box is held in equilibrium by the rope.

(i) Show that the normal reaction force between the box and the slope is 72.5 newtons, correct to three significant figures. *(3 marks)*

(ii) The coefficient of friction between the box and the slope is 0.32. Find the magnitude of the maximum value of the frictional force which can act on the box. *(2 marks)*

(iii) Find the least possible tension in the rope to prevent the box from moving down the slope. *(4 marks)*

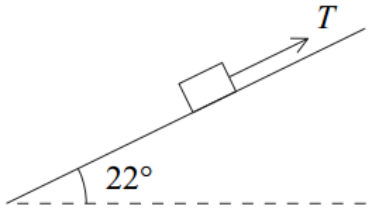
(iv) Find the greatest possible tension in the rope. *(3 marks)*

(v) Show that the mass of the box is approximately 8.16 kg. *(1 mark)*

June 2006

4 A block is being pulled up a rough plane inclined at an angle of 22° to the horizontal by a rope parallel to the plane, as shown in the diagram.

The mass of the block is 0.7 kg, and the tension in the rope is T newtons.



(a) Draw a diagram to show the forces acting on the block. *(1 mark)*

(b) Show that the normal reaction force between the block and the plane has magnitude 6.36 newtons, correct to three significant figures. *(3 marks)*

(c) The coefficient of friction between the block and the plane is 0.25. Find the magnitude of the frictional force acting on the block during its motion. *(2 marks)*

June 2007

6 A box, of mass 3 kg, is placed on a slope inclined at an angle of 30° to the horizontal. The box slides down the slope. Assume that air resistance can be ignored.

A simple model assumes that the slope is smooth.

(i) Draw a diagram to show the forces acting on the box. *(1 mark)*

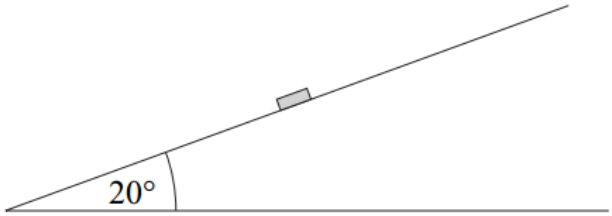
A revised model assumes that the slope is rough. The box slides down the slope from rest, travelling 5 metres in 2 seconds.

(ii) Find the magnitude of the friction force acting on the box. *(3 marks)*

(iii) Find the coefficient of friction between the box and the slope. *(5 marks)*

January 2008

5 A puck, of mass 0.2 kg, is placed on a slope inclined at 20° above the horizontal, as shown in the diagram.



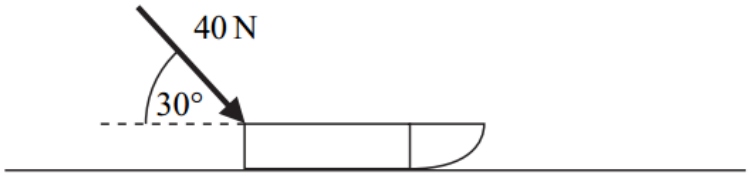
The puck is hit so that initially it moves directly up the slope.

(a) A model assumes that the surface is rough and that the coefficient of friction between the puck and the surface is 0.5 .

(i) Show that the magnitude of the friction force acting on the puck during this motion is 0.921 N, correct to three significant figures. *(3 marks)*

January 2009

5 A sledge of mass 8 kg is at rest on a rough horizontal surface. A child tries to move the sledge by pushing it with a pole, as shown in the diagram, but the sledge **does not move**. The pole is at an angle of 30° to the horizontal and exerts a force of 40 newtons on the sledge.



Model the sledge as a particle.

(a) Draw a diagram to show the four forces acting on the sledge. *(1 mark)*

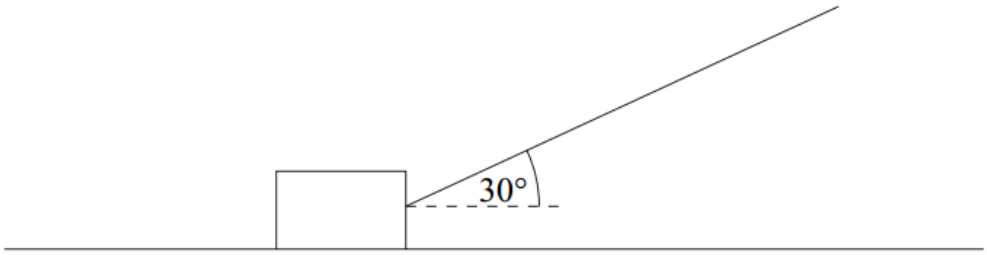
(b) Show that the normal reaction force between the sledge and the surface has magnitude 98.4 N. *(3 marks)*

(c) Find the magnitude of the friction force that acts on the sledge. *(2 marks)*

(d) Find the least possible value of the coefficient of friction between the sledge and the surface. *(3 marks)*

June 2009

8 The diagram shows a block, of mass 20 kg, being pulled along a rough horizontal surface by a rope inclined at an angle of 30° to the horizontal.



The coefficient of friction between the block and the surface is μ. Model the block as a particle which slides on the surface.

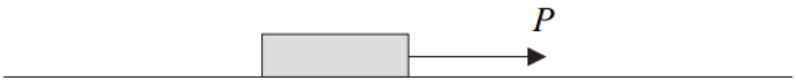
(a) If the tension in the rope is 60 newtons, the block is in equilibrium.

(i) Show that the magnitude of the normal reaction force acting on the block is 166 N. *(3 marks)*

(ii) Find μ. *(4 marks)*

June 2010

2 A block, of mass 10 kg, is at rest on a rough horizontal surface, when a horizontal force, of magnitude P newtons, is applied to the block, as shown in the diagram.



The coefficient of friction between the block and the surface is 0.5.

(a) Draw and label a diagram to show all the forces acting on the block. *(1 mark)*

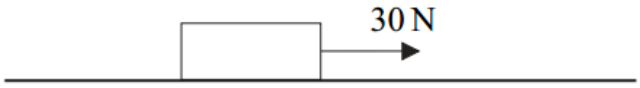
(b) (i) Calculate the magnitude of the normal reaction force acting on the block. *(1 mark)*

(ii) Find the maximum possible magnitude of the friction force between the block and the surface. *(1 mark)*

(iii) Given that $P = 30$, state the magnitude of the friction force acting on the block. *(1 mark)*

June 2011

2 A wooden block, of mass 4 kg, is placed on a rough horizontal surface. The coefficient of friction between the block and the surface is 0.3. A horizontal force, of magnitude 30 newtons, acts on the block and causes it to accelerate.



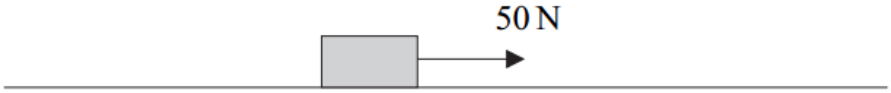
(a) Draw a diagram to show all the forces acting on the block. *(1 mark)*

(b) Calculate the magnitude of the normal reaction force acting on the block. *(1 mark)*

(c) Find the magnitude of the friction force acting on the block. *(2 marks)*

January 2012

2 A block, of mass 4 kg, is made to move in a straight line on a rough horizontal surface by a horizontal force of 50 newtons, as shown in the diagram.



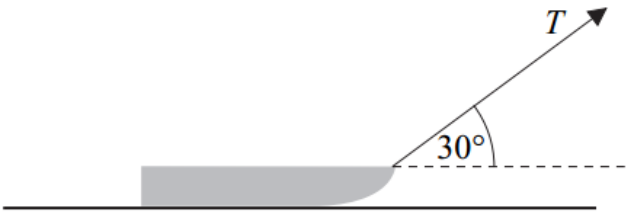
Assume that there is no air resistance acting on the block.

(a) Draw a diagram to show all the forces acting on the block. *(1 mark)*

(b) Find the magnitude of the normal reaction force acting on the block. *(1 mark)*

June 2012

6 A child pulls a sledge, of mass 8 kg, along a rough horizontal surface, using a light rope. The coefficient of friction between the sledge and the surface is 0.3. The tension in the rope is T newtons. The rope is kept at an angle of 30° to the horizontal, as shown in the diagram.



Model the sledge as a particle.

(a) Draw a diagram to show all the forces acting on the sledge. *(1 mark)*

(b) Find the magnitude of the normal reaction force acting on the sledge, in terms of T. *(3 marks)*

January 2013

3 A box, of mass 3 kg, is placed on a rough slope inclined at an angle of 40° to the horizontal. It is released from rest and slides down the slope.

(a) Draw a diagram to show the forces acting on the box. *(1 mark)*

(b) Find the magnitude of the normal reaction force acting on the box. *(2 marks)*

(c) The coefficient of friction between the box and the slope is 0.2. Find the magnitude of the friction force acting on the box. *(2 marks)*

(d) Find the acceleration of the box. *(3 marks)*

(e) State an assumption that you have made about the forces acting on the box. *(1 mark)*

7 A block of mass 30 kg is dragged across a rough horizontal surface by a rope that is at an angle of 20° to the horizontal. The coefficient of friction between the block and the surface is 0.4.

(a) The tension in the rope is 150 newtons.

(i) Draw a diagram to show the forces acting on the block as it moves. *(2 marks)*

(ii) Show that the magnitude of the normal reaction force on the block is 243 newtons, correct to three significant figures. *(3 marks)*

(iii) Find the magnitude of the friction force acting on the block. *(2 marks)*

(iv) Find the acceleration of the block. *(4 marks)*

(b) When the block is moving, the tension is reduced so that the block moves at a constant speed, with the angle between the rope and the horizontal unchanged. Find the tension in the rope when the block is moving at this constant speed. *(5 marks)*

(c) If the block were made to move at a greater **constant** speed, again with the angle between the rope and the horizontal unchanged, how would the tension in this case compare to the tension found in part **(b)**? *(1 mark)*