

# Newton's Laws Challenge

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## Challenge 1

A skier slides in a straight line directly down a slope inclined at  $30^\circ$  to the horizontal. The coefficient of friction between her skis and the slope is 0.3. The skier and her equipment are to be modelled as a particle of mass 80 kg. Assume that there is no air resistance present.

- (a) Draw a diagram to show the forces acting on the skier. *(1 mark)*
- (b) (i) Find the magnitude of the normal reaction force acting on the skier. *(2 marks)*
- (ii) Show that the magnitude of the friction force acting on the skier is 204 N to three significant figures. *(2 marks)*
- (c) Find the acceleration of the skier. *(4 marks)*



## Challenge 2

A rough plane is inclined at an angle of  $40^\circ$  to the horizontal. A particle, of mass 5 kg, is sliding down the plane.

- (a) Draw a diagram to show the forces acting on the particle. *(1 mark)*
- (b) Find the magnitude of the normal reaction force acting on the particle. *(2 marks)*
- (c) The coefficient of friction between the particle and the plane is 0.2. Show that the magnitude of the friction force acting on the particle is 7.51 N, correct to three significant figures. *(2 marks)*
- (d) Show that the acceleration of the particle is  $4.80 \text{ m s}^{-2}$ , correct to three significant figures. *(4 marks)*
- (e) Find the distance that the particle travels as its speed increases from  $2 \text{ m s}^{-1}$  to  $10 \text{ m s}^{-1}$ . *(3 marks)*



## Challenge 3

A child slides down a steep, straight slide that is inclined at  $60^\circ$  to the horizontal. The child has mass 30 kg and the coefficient of friction between the slide and the child is 0.6. Assume that there is no air resistance.

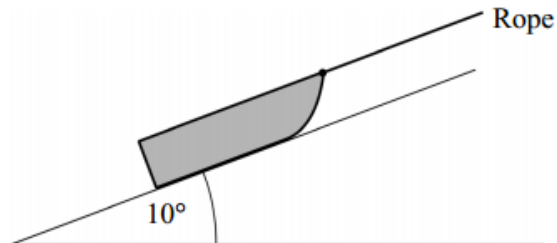
- (a) Draw a diagram to show the forces acting on the child, while sliding down the slide. *(1 mark)*
- (b) Calculate the magnitude of the normal reaction force on the child. *(2 marks)*
- (c) Show that the magnitude of the friction force that acts on the child is 88.2 N. *(2 marks)*
- (d) Calculate the acceleration of the child. *(4 marks)*
- (e) What modelling assumption have you made about the child in your solution? *(1 mark)*



# Final Challenge

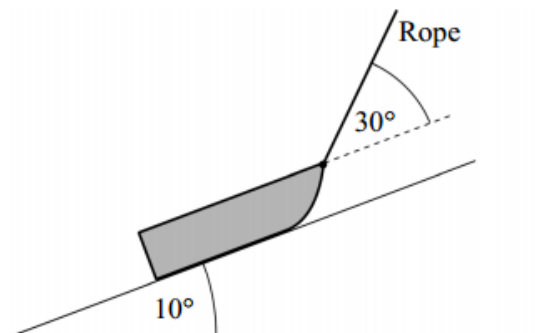
A sledge, of mass 12 kg, is pulled up a rough slope which is inclined at an angle of  $10^\circ$  to the horizontal. The coefficient of friction between the slope and the sledge is 0.2.

- (a) The sledge is pulled by a rope that is parallel to the slope, as shown in the diagram.



- (i) Draw a diagram to show the forces acting on the sledge. (1 mark)
- (ii) Find the magnitude of the normal reaction force acting on the sledge. (2 marks)
- (iii) Given that the acceleration of the sledge is  $0.5 \text{ m s}^{-2}$ , show that the tension in the rope is approximately 50 N. (4 marks)

- (b) The sledge is then pulled with the rope at an angle of  $30^\circ$  to the slope, as shown in the diagram.



Find the acceleration of the sledge if the tension in the rope is 60 N.

(7 marks)

- (c) Write down **two** modelling assumptions that you have made.

(2 marks)

