

Questions

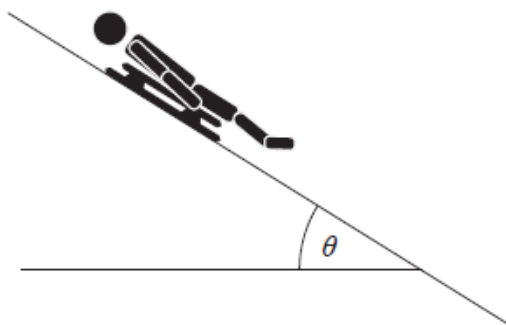
Q1.

The luge is an event at the Winter Olympics. An athlete lies on a small sledge and races down an icy track, feet first.



Source: www.wtop.com

(a) An athlete accelerates down a straight section of the track as shown. The track is at an angle θ to the horizontal.



Draw a free-body force diagram for the sledge and athlete.
You should consider the relative sizes of the forces when drawing your diagram.

(4)



(b) The mass of the athlete is one of the factors that affects her time to complete the race.

(i) Explain why the mass of the athlete has little effect on the initial acceleration.

(3)

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(ii) Explain, in terms of forces, why the athlete reaches a maximum velocity.

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(iii) It is stated that the maximum speed is greater for athletes of greater mass.

Suggest why this is only correct up to a certain mass.

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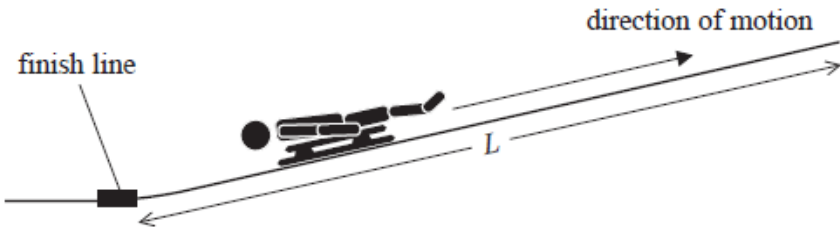
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(c) After the finish line there is a straight, uphill section of track for the sledge to decelerate in. The maximum permitted gradient of this section is 20 %.



(i) Show that a track with a gradient of 20% is at an angle to the horizontal of about 11°.

(1)

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(ii) An athlete reaches the finish line at a velocity of 33 m s^{-1} . She then applies a minimum

braking force of 240 N as she moves along the uphill section of track to help her come to a stop.

Calculate the minimum uphill length of track L that should be available for braking. You should ignore all frictional forces other than those applied by the athlete.

mass of sledge and athlete = 95 kg

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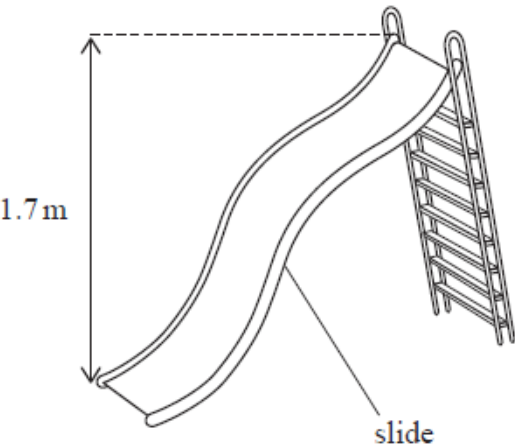
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$L =$

(Total for question = 18 marks)

Q2.

A child's slide has a vertical height of 1.7 m as shown.



(a) A child starts from rest at the top of the slide and moves down the slide.

The resistive forces acting on the child can be ignored.

(i) Explain why the equations of motion should **not** be used to determine the maximum speed of the child.

You should consider the shape of the slide.

(3)

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(ii) The child has a mass of 24 kg.

Determine the maximum speed v of the child on the slide.

(3)

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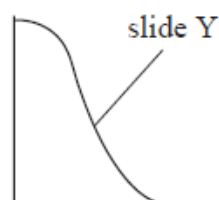
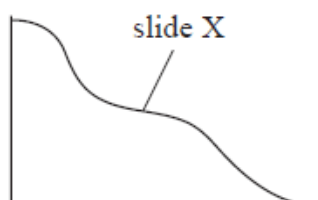
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$v =$

(b) Two slides, X and Y, have the same height.

Slide X is longer than slide Y, as shown.



A child moves from rest down slide X and reaches a maximum speed v_X .

A second child moves from rest down slide Y and reaches a maximum speed v_Y .

The child on slide Y has a greater mass than the child on slide X.

The resistive forces acting on both children can be ignored.

Explain how v_x compares with v_y .

(3)

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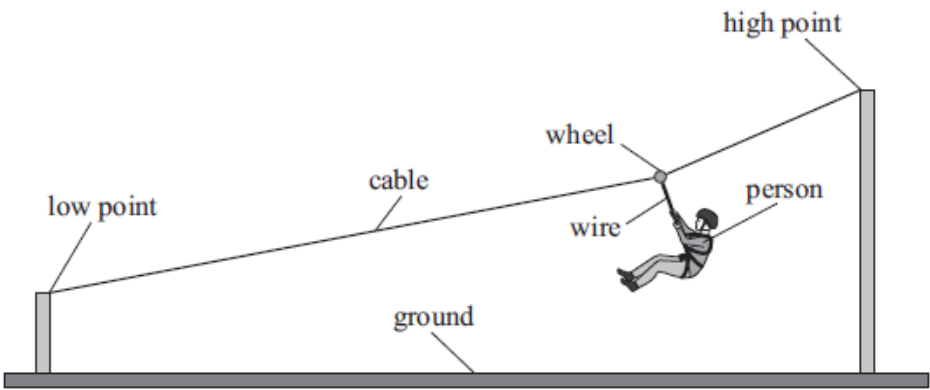
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(Total for question = 9 marks)

Q3.

A 'zip-line' consists of a cable fixed at two points, one higher than the other.

A person hangs from a wire attached to a wheel, as shown. The wheel can move along the cable. The wheel moves the person along the cable.



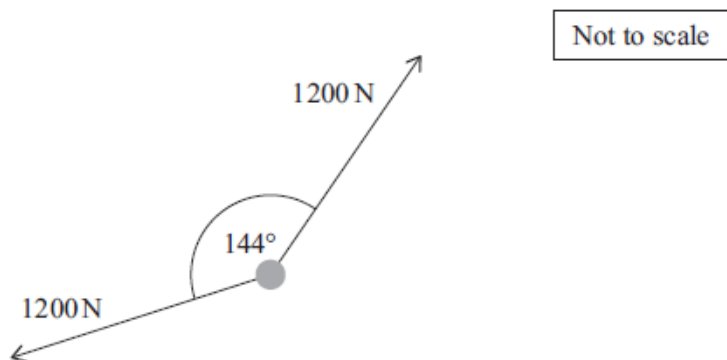
(a) In the position shown, the person is accelerating.

Complete the free-body force diagram below to show the three forces acting on the person in this position.

(3)



(b) At a particular instant, the tension in the cable is 1200 N and the angle formed by the cable at the wheel is 144° , as shown.



(i) Show, by calculation, that the force on the wheel from the cable is about 740 N.

(2)

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(ii) There is a force on the wheel from the wire of 800 N.

The angle between the force from the cable and the 800 N force from the wire is 150° .

Determine the magnitude of the resultant force on the wheel using a scaled vector diagram.

You should ignore the weight of the wheel.

(4)

Resultant force on the wheel = ...

(c) People take turns at moving along the zip-line from the high point to the low point. The people are initially at rest at the high point.

Explain why the speeds of people with different masses are always about the same when they reach the low point.

(3)

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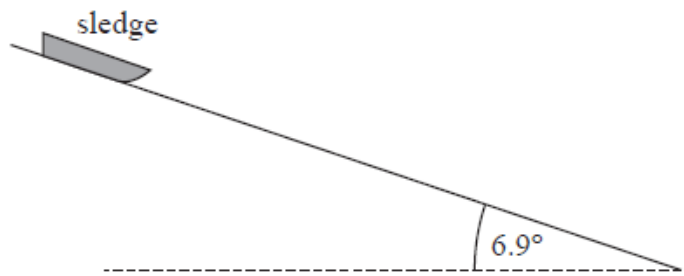
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(Total for question = 12 marks)

Q4.

A sledge accelerates, due to gravity, from rest down a frictionless slope. Air resistance can be ignored. The slope is at an angle of 6.9° to the horizontal, as shown.



(a) Complete the free-body force diagram below for the sledge.

(2)



(b) The slope has a total length of 60 m.

(i) Show that the initial acceleration of the sledge along the slope is about 1 m s^{-2} .

(2)

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(ii) Determine the speed of the sledge at the end of the slope.

(2)

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Speed at end of slope = ...

(iii) Determine the time taken for the sledge to travel to the end of the slope.

(2)

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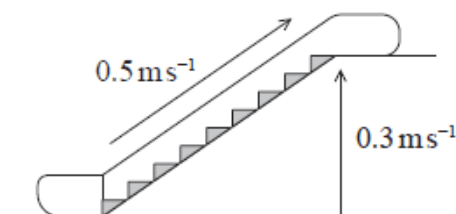
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Time taken = ...

(Total for question = 8 marks)

Q5.

The steps on an escalator move with a speed of 0.5 m s^{-1} . The vertical component of their velocity is 0.3 m s^{-1} upwards.



Which of the following is the horizontal component of velocity for the escalator steps?

(1)

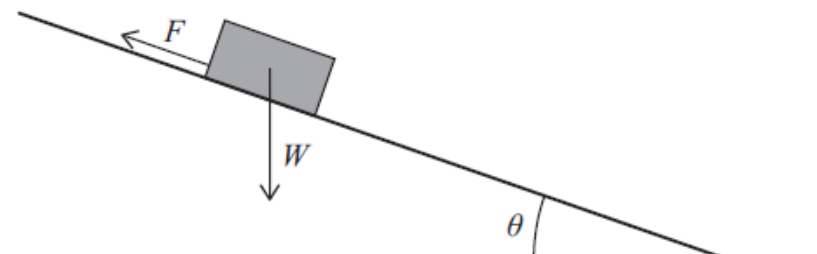
- ☐ **A** 0.2 m s^{-1}
- ☐ **B** 0.4 m s^{-1}
- ☐ **C** 0.5 m s^{-1}
- ☐ **D** 0.8 m s^{-1}

(Total for question = 1 mark)

Q6.

Answer the question with a cross in the box you think is correct (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

A box of weight W slides down a ramp. The ramp is at an angle θ to the horizontal. A frictional force F acts on the box, as shown.



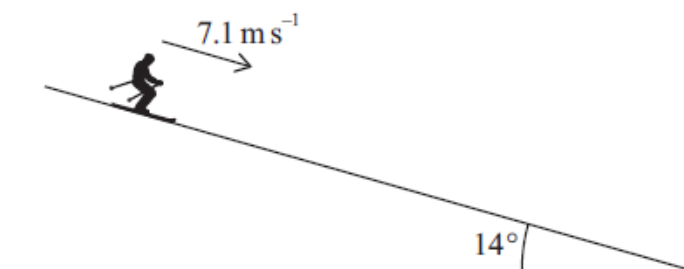
Which of the following is correct when the box moves at a constant speed?

- ☒ **A** $F = W\cos\theta$
- ☒ **B** $F < W\cos\theta$
- ☒ **C** $F = W\sin\theta$
- ☒ **D** $F < W\sin\theta$

(Total for question = 1 mark)

Q7.

A person on skis slides down a slope. The slope is at an angle of 14° to the horizontal. The initial speed of the person is 7.1 m s^{-1} , as shown.



The resistive forces acting on the person are negligible.

Calculate the speed of the person after moving 15 m down the slope.

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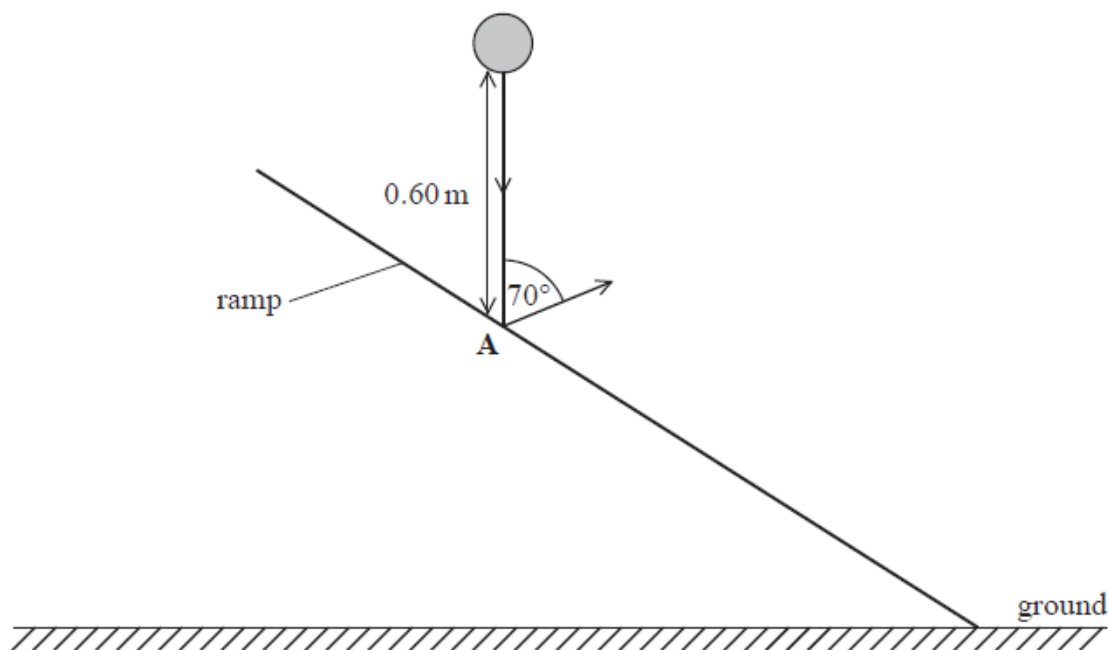
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Speed = ...

(Total for question = 3 marks)

Q8.

A ball falls through a vertical height of 0.60 m before bouncing at point A on a ramp, as shown.



(a) Show that the velocity of the ball immediately before the bounce is about 3 m s^{-1} .

(2)

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(b) Kinetic energy is conserved as the ball bounces off the ramp. The ball bounces at an angle of 70° to the vertical.

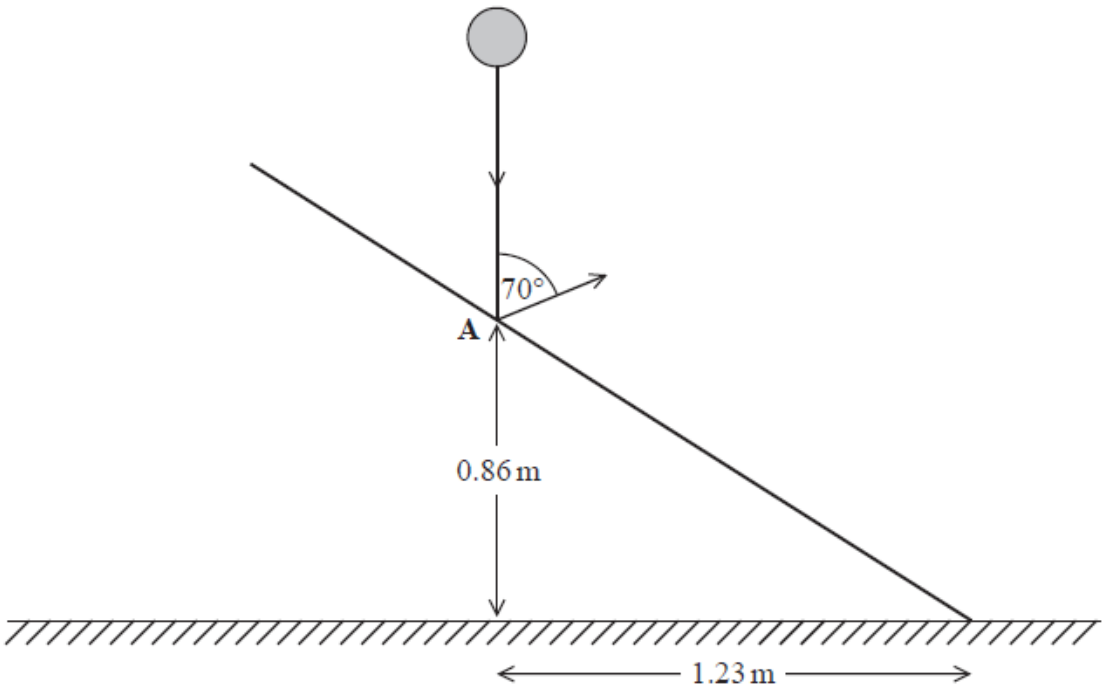
State expressions for the horizontal and vertical components of velocity of the ball immediately after the bounce.

(2)

Horizontal component = ...

Vertical component = ...

(c) Point A is 0.86 m vertically above the ground and 1.23 m horizontally from the end of the ramp as shown.



Deduce whether the ball will bounce a second time on the ramp.

(4)

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