Additional Instructions for candidates

Show all working in your answers to numerical questions. Some credit will be given for unsimplified answers. Credit cannot be given for an incorrect answer, unless it is accompanied by details of the working. Appropriate units must be included.

Note:

- When candidates are asked to 'show that':
  - a candidate should calculate their own answer to three significant figures and use this subsequently.
  - a candidate who is unable to determine the required value should use the value given by the examiner in subsequent questions.
- A spare set of diagrams has been provided in the back of the answer booklet for you to use if required. If you use the spare diagrams, you **MUST** indicate you have done so in your answer to that question.

Question 1

For Marker Use Only

A Formula 1 racing car is travelling instantaneously southwards while rounding a curve towards the west.

(a) In what direction is the net force on the car? (1 mark)

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The maximum horizontal acceleration of the car is 3.50 x the acceleration due to gravity (i.e. '3.50 g') before the car will skid. The radius of curvature of the bend is 150 m, the mass of the driver is 80.0 kg.

(b) Determine the maximum speed the car can achieve on the bend without skidding. (2 marks)

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(c) (i) Calculate the net force on the driver. (1 mark)

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(ii) Hence determine the magnitude of the total force the car exerts on the driver. (2 marks)

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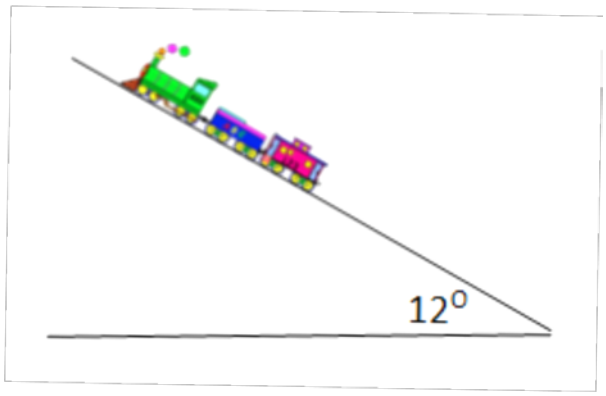
Question 2

For Marker Use Only

A train of total mass 500 tonnes is moving up a 12.0° incline at a steady speed of 20.0 m s^{-1}. Assume that the frictional forces are 15.0% of the weight.



(a) (i) On the diagram, draw and label clearly the 3 components of the force on the train due to the surface and any other individual force(s) on the train. (2 marks)

(ii) Indicate also the **net** force. (1 mark)

(b) Show that the force up the slope has a magnitude of approximately 1800 kN. (3 marks)

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(c) Calculate the power output of the train's engine. (1 mark)

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Question 2 continues.

Question 2 (continued)

For Marker Use Only

While the train is still travelling up the slope at 20.0 m s^{-1}, a 50.0 tonne carriage detaches from the rear of the train. The friction remains the same.

(d) Show that the carriage will initially accelerate down the slope at approximately 4 m s^{-2}. (2 marks)

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(e) How much further up the slope will the carriage travel before temporarily coming to rest? (2 marks)

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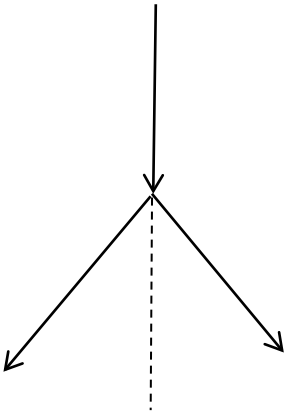
Question 3

For Marker Use Only

In a game of ten-pin bowling, a 6.00 kg ball is initially travelling at 4.50 m s^{-1} southwards. After colliding with a pin of mass 1.50 kg, the ball travels at 3.50 m s^{-1} in a direction S 15.0° E.



(a) What was the ball's initial momentum? (1 mark)

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(b) Calculate the final momentum of the ball. (1 mark)

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(c) Show that the North-South component of the pin's momentum after the collision has a value of approximately 7. (2 marks)

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Question 3 continues.

Question 3 (continued)

For Marker Use Only

(d) By using components, or otherwise, find the velocity of the pin after the collision.

(3 marks)

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Question 4

For Marker Use Only

A space traveller in a Space Station orbiting Mars will float freely and is often said to be *weightless*.

(a) Discuss the term *weightless* as used in this context. (2 marks)

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Some constants for Mars

Mass	M 6.42×10^{23} kg	
Radius of planet	R 3.40×10^{6} m	(3400 km)
Period of rotation	T 8.86×10^{4} s	(24.6 hours)

(b) Determine the acceleration due to gravity on Mars's surface. (1 mark)

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To support a proposed human settlement on Mars, a communication satellite is to be placed in synchronous orbit over the settlement. This satellite will be constantly over a point on Mars's equator.

(c) What is the period of orbit of a Mars-synchronous satellite? (1 mark)

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Question 4 continues.

Question 4 (continued)

For Marker Use Only

(d) With the aid of suitable diagrams, explain why it is not possible for a satellite to remain in a fixed position over a point which is not on the equator. (2 marks)

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(e) Calculate the radius of orbit of the satellite. (2 marks)

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(f) Another satellite is orbiting at twice the radius of the synchronous satellite. Determine, in hours, its period of orbit. (2 marks)

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Question 5

For Marker Use Only

During the Apollo 14 mission to the Moon in 1971, an astronaut hit several golf balls.

On horizontal ground, one hit caused the golf ball to leave the club with a speed of 30.0 m s^{-1} at 40.0° to the horizontal.

The ball remained in the air for 23.2 seconds before landing.

(a) Use this information to show that the acceleration due to gravity at the Moon's surface has a magnitude of approximately 2 m s^{-2}. (2 marks)

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(b) How far from the start point did the ball land? (1 mark)

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Another identical hit was in a different direction towards a 100.0 m high hill 150.0 m away.

(c) Did the ball clear the top of the hill? Show your reasoning. (3 marks)

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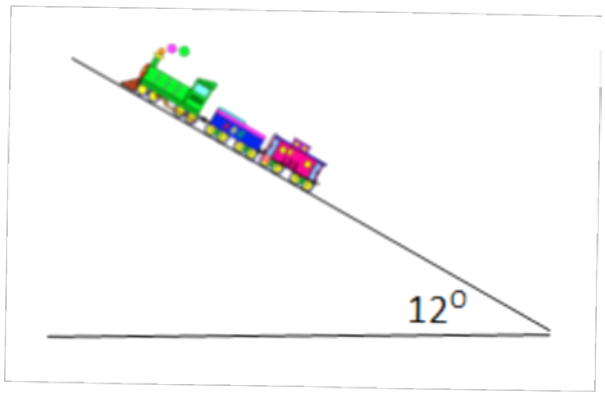
SPARE DIAGRAM

For Marker Use Only

Question 2



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