

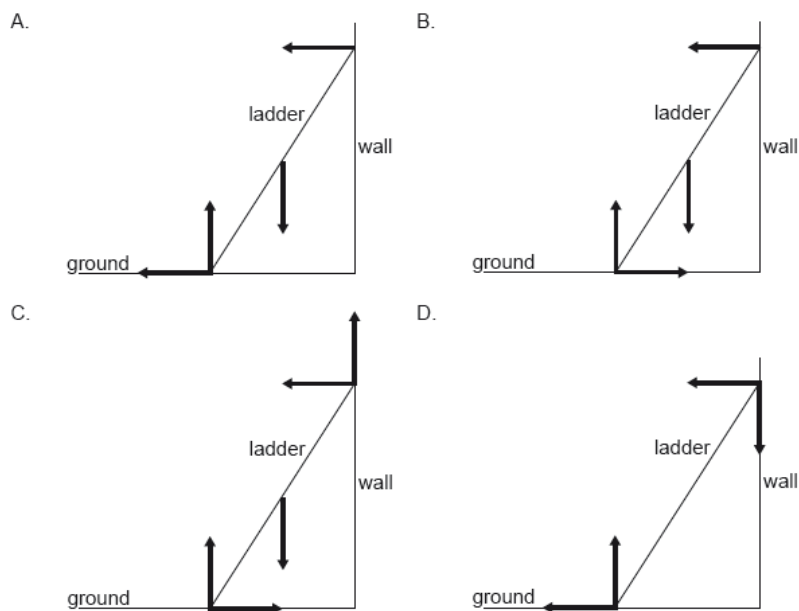
R2019_2 [106 marks]

1. An object is projected vertically upwards at time $t = 0$. Air resistance is negligible. The object passes the same point above its starting position at times 2 s and 8 s. [1 mark]

If $g = 10 \text{ m s}^{-2}$, what is the initial speed of the object?

- A. 50
- B. 30
- C. 25
- D. 4

2. A uniform ladder resting in equilibrium on rough ground leans against a smooth wall. Which diagram correctly shows the forces acting on the ladder? [1 mark]



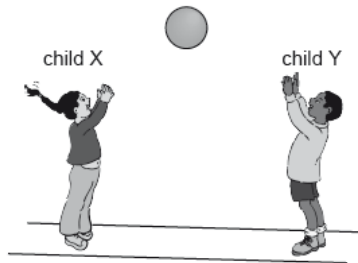
3. An object falls from rest from a height h close to the surface of the Moon. The Moon has no atmosphere. [1 mark]

When the object has fallen to height $\frac{h}{4}$ above the surface, what is

$$\frac{\text{kinetic energy of the object at } \frac{h}{4}}{\text{gravitational potential energy of the object at } h} ?$$

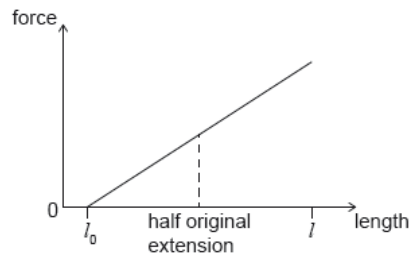
- A. $\frac{3}{4}$
- B. $\frac{4}{3}$
- C. $\frac{9}{16}$
- D. $\frac{16}{9}$

4. Child X throws a ball to child Y. The system consists of the ball, the children and the Earth. What is true for the system when the ball has been caught by Y? [1 mark]



[Source: <https://pixabay.com/en/playing-ball-kids-boy-girl-31339/>]

- A. The momentum of child Y is equal and opposite to the momentum of child X.
 B. The speed of rotation of the Earth will have changed.
 C. The ball has no net momentum while it is in the air.
 D. The total momentum of the system has not changed.
5. An increasing force acts on a metal wire and the wire extends from an initial length l_0 to [1 mark]
 a new length l . The graph shows the variation of force with length for the wire. The energy required to extend the wire from l_0 to l is E .



The wire then contracts to half its original extension.

What is the work done by the wire as it contracts?

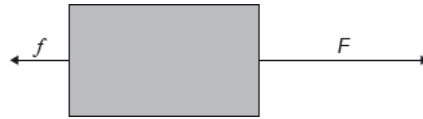
- A. $0.25 E$
 B. $0.50 E$
 C. $0.75 E$
 D. E
6. The distances between successive positions of a moving car, measured at equal time [1 mark]
 intervals, are shown.



The car moves with

- A. acceleration that increases linearly with time.
 B. acceleration that increases non-linearly with time.
 C. constant speed.
 D. constant acceleration.

7. An object is moving in a straight line. A force F and a resistive force f act on the object [1 mark] along the straight line.



Both forces act for a time t .

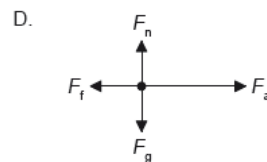
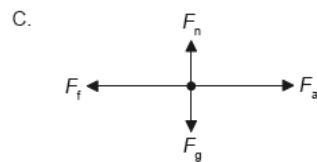
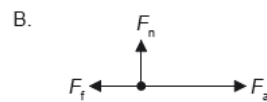
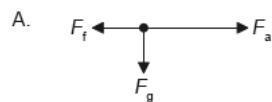
What is the rate of change of momentum with time of the object during time t ?

- A. $F + f$
 B. $F - f$
 C. $(F + f)t$
 D. $(F - f)t$
8. A motor of input power 160 W raises a mass of 8.0 kg vertically at a constant speed of 0.50 m s^{-1} . [1 mark]

What is the efficiency of the system?

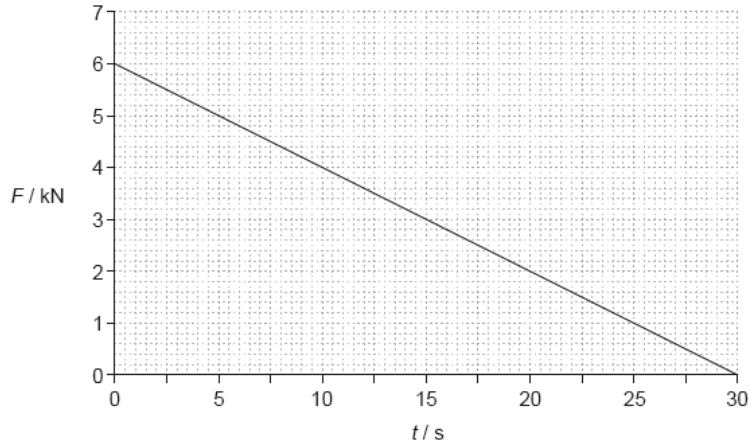
- A. 0.63%
 B. 25%
 C. 50%
 D. 100%

9. A box is accelerated to the right across rough ground by a horizontal force F_a . The force of friction is F_f . The weight of the box is F_g and the normal reaction is F_n . Which is the free-body diagram for this situation? [1 mark]



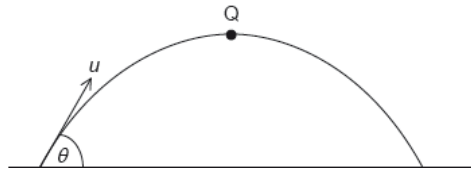
10. The graph shows the variation with time t of the force F acting on an object of mass $15\ 000\text{ kg}$. [1 mark]

The object is at rest at $t = 0$.



What is the speed of the object when $t = 30\text{ s}$?

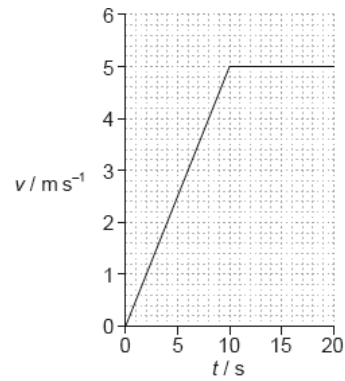
- A. 0.18 m s^{-1}
 - B. 6 m s^{-1}
 - C. 12 m s^{-1}
 - D. 180 m s^{-1}
11. A ball of mass m is thrown with an initial speed of u at an angle θ to the horizontal as shown. Q is the highest point of the motion. Air resistance is negligible. [1 mark]



What is the momentum of the ball at Q?

- A. zero
- B. $mu \cos \theta$
- C. mu
- D. $mu \sin \theta$

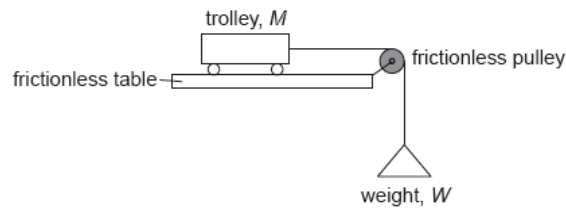
12. A boy runs along a straight horizontal track. The graph shows how his speed v varies with time t . [1 mark]



After 15 s the boy has run 50 m. What is his instantaneous speed and his average speed when $t = 15$ s?

	Instantaneous speed / m s^{-1}	Average speed / m s^{-1}
A.	3.3	3.3
B.	3.3	5.0
C.	5.0	3.3
D.	5.0	5.0

13. A weight W is tied to a trolley of mass M by a light string passing over a frictionless pulley. The trolley has an acceleration a on a frictionless table. The acceleration due to gravity is g . [1 mark]



What is W ?

- A. $\frac{Mag}{(g-a)}$
 B. $\frac{Mag}{(g+a)}$
 C. $\frac{Ma}{(g-a)}$
 D. $\frac{Ma}{(g+a)}$

14. Two balls X and Y with the same diameter are fired horizontally with the same initial momentum from the same height above the ground. The mass of X is greater than the mass of Y. Air resistance is negligible. [1 mark]

What is correct about the horizontal distances travelled by X and Y and the times taken by X and Y to reach the ground?

	Horizontal distances	Time to reach ground
A.	X and Y the same	X and Y times the same
B.	X and Y the same	X takes a shorter time than Y
C.	X less than Y	X and Y times the same
D.	X less than Y	X takes a shorter time than Y

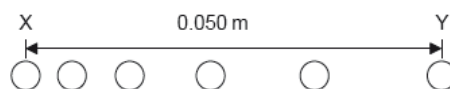
15. A parachutist of total mass 70 kg is falling vertically through the air at a constant speed of 8 m s^{-1} . [1 mark]

What is the total upward force acting on the parachutist?

- A. 0 N
 B. 70 N
 C. 560 N
 D. 700 N
16. A stopper of mass 8 g leaves the opening of a container that contains pressurized gas. The stopper accelerates from rest for a time of 16 ms and leaves the container at a speed of 20 m s^{-1} . [1 mark]

What is the order of magnitude of the force acting on the stopper?

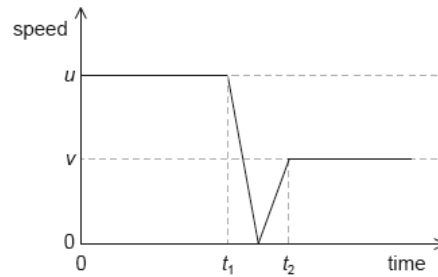
- A. 10^{-3} N
 B. 10^0 N
 C. 10^1 N
 D. 10^3 N
17. A ball starts from rest and moves horizontally. Six positions of the ball are shown at time intervals of 1.0 ms. The horizontal distance between X, the initial position, and Y, the final position, is 0.050 m. [1 mark]



What is the average acceleration of the ball between X and Y?

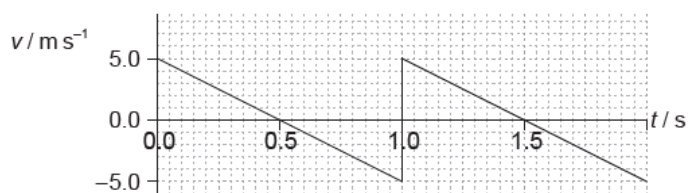
- A. 2000 m s^{-2}
 B. 4000 m s^{-2}
 C. 5000 m s^{-2}
 D. 8000 m s^{-2}

18. A ball of mass m collides with a vertical wall with an initial horizontal speed u and rebounds with a horizontal speed v . The graph shows the variation of the speed of the ball with time. [1 mark]



What is the magnitude of the mean net force on the ball during the collision?

- A. $\frac{m(u-v)}{(t_2+t_1)}$
 B. $\frac{m(u-v)}{(t_2-t_1)}$
 C. $\frac{m(u+v)}{(t_2+t_1)}$
 D. $\frac{m(u+v)}{(t_2-t_1)}$
19. The variation of the displacement of an object with time is shown on a graph. What does the area under the graph represent? [1 mark]
- A. No physical quantity
 B. Velocity
 C. Acceleration
 D. Impulse
20. An object is thrown upwards. The graph shows the variation with time t of the velocity v of the object. [1 mark]



What is the total displacement at a time of 1.5 s, measured from the point of release?

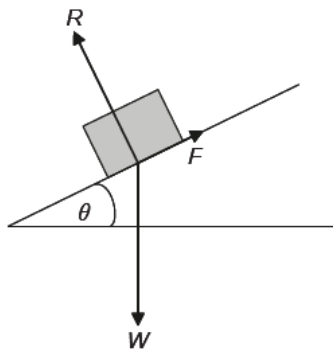
- A. 0 m
 B. 1.25 m
 C. 2.50 m
 D. 3.75 m

21. An object is released from a stationary hot air balloon at height h above the ground. [1 mark]

An identical object is released at height h above the ground from another balloon that is rising at constant speed. Air resistance is negligible. What does **not** increase for the object released from the rising balloon?

- A. The distance through which it falls
- B. The time taken for it to reach the ground
- C. The speed with which it reaches the ground
- D. Its acceleration

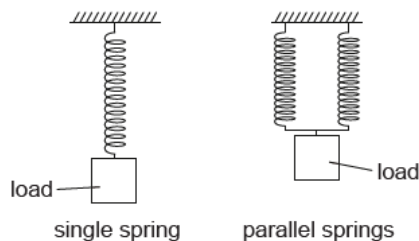
22. The diagram shows the forces acting on a block resting on an inclined plane. The angle θ is adjusted until the block is just at the point of sliding. R is the normal reaction, W the weight of the block and F the maximum frictional force. [1 mark]



not to scale

What is the maximum coefficient of static friction between the block and the plane?

- A. $\sin \theta$
 - B. $\cos \theta$
 - C. $\tan \theta$
 - D. $\frac{1}{\tan \theta}$
23. A system that consists of a single spring stores a total elastic potential energy E_p when [1 mark] a load is added to the spring. Another identical spring connected in parallel is added to the system. The same load is now applied to the parallel springs.



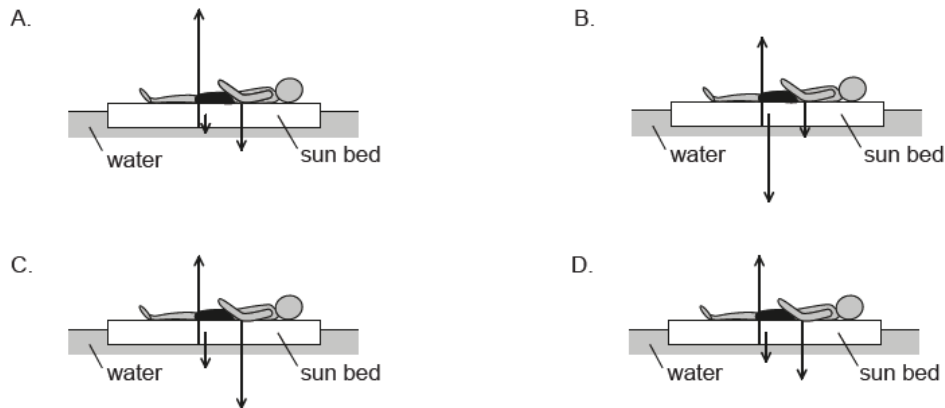
What is the total elastic potential energy stored in the changed system?

- A. E_p
- B. $\frac{E_p}{2}$
- C. $\frac{E_p}{4}$
- D. $\frac{E_p}{8}$

24. A moving system undergoes an explosion. What is correct for the momentum of the system and the kinetic energy of the system when they are compared immediately before and after the explosion? [1 mark]

	Momentum	Kinetic energy
A.	conserved	increased
B.	conserved	conserved
C.	increased	conserved
D.	increased	increased

25. A sunbather is supported in water by a floating sun bed. Which diagram represents the magnitudes of the forces acting on the sun bed? [1 mark]

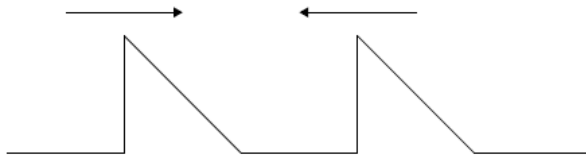


26. A toy car of mass 0.15 kg accelerates from a speed of 10 cm s^{-1} to a speed of 15 cm s^{-1} . What is the impulse acting on the car? [1 mark]

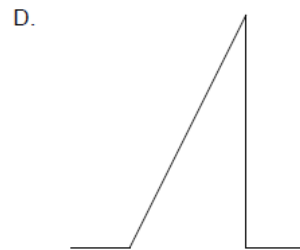
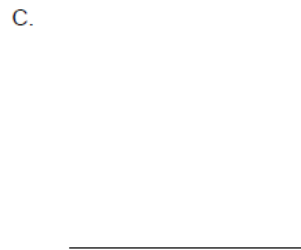
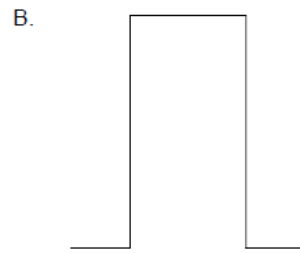
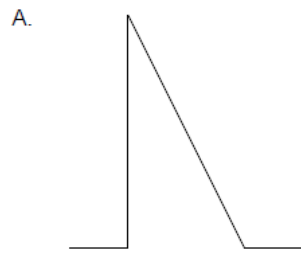
- A. 7.5 mN s
 B. 37.5 mN s
 C. 0.75 N s
 D. 3.75 N s

27. Two pulses are travelling towards each other.

[1 mark]



What is a possible pulse shape when the pulses overlap?



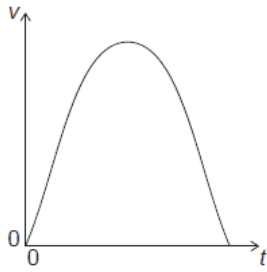
28. An object is released from rest in the gravitational field of the Earth. Air resistance is negligible. How far does the object move during the fourth second of its motion?

[1 mark]

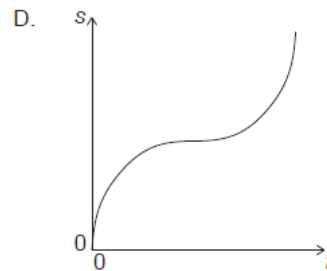
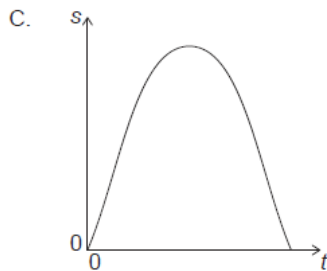
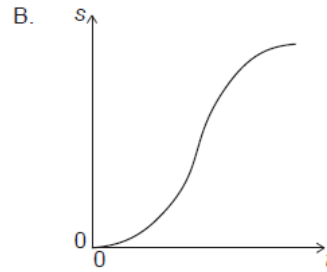
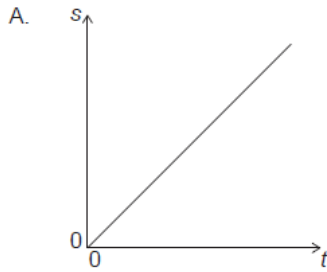
- A. 15 m
- B. 25 m
- C. 35 m
- D. 45 m

29. The graph shows the variation of speed v of an object with time t .

[1 mark]



Which graph shows how the distance s travelled by the object varies with t ?



30. Two boxes in contact are pushed along a floor with a force F . The boxes move at a constant speed. Box X has a mass m and box Y has a mass $2m$.

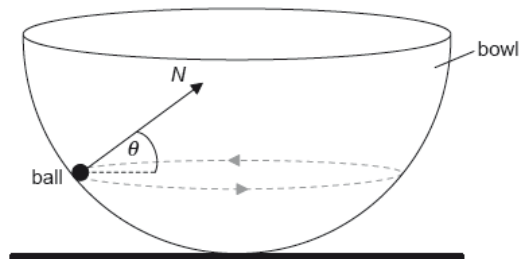
[1 mark]



What is the resultant force acting on Y?

- A. 0
- B. $\frac{F}{2}$
- C. F
- D. $2F$

A small ball of mass m is moving in a horizontal circle on the inside surface of a frictionless hemispherical bowl.



The normal reaction force N makes an angle θ to the horizontal.

31a. State the direction of the resultant force on the ball.

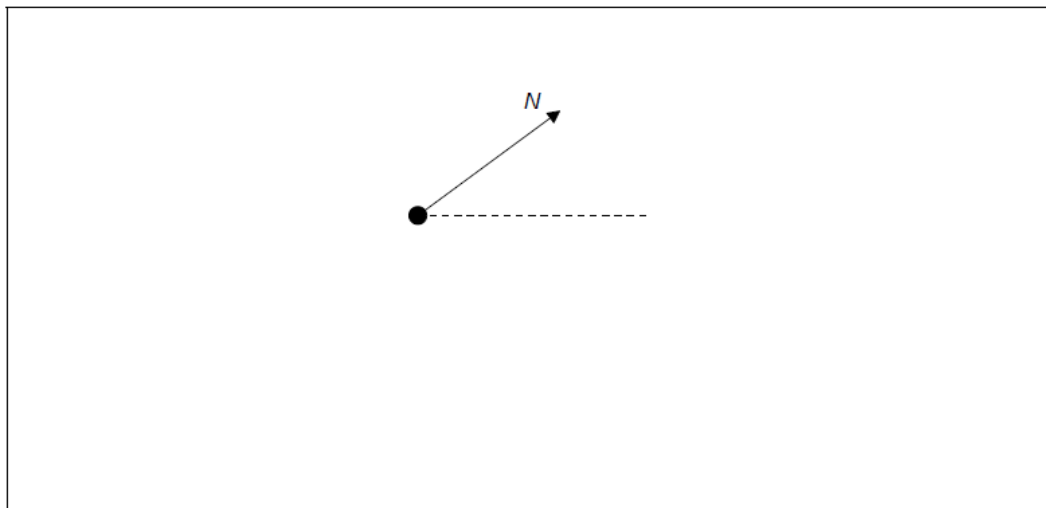
[1 mark]

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31b. On the diagram, construct an arrow of the correct length to represent the weight of the ball.



31c. Show that the magnitude of the net force F on the ball is given by the following equation.

[3 marks]

$$F = \frac{mg}{\tan \theta}$$

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31d. The radius of the bowl is 8.0 m and $\theta = 22^\circ$. Determine the speed of the ball.

[4 marks]

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31e. Outline whether this ball can move on a horizontal circular path of radius equal to the radius of the bowl. [2 marks]

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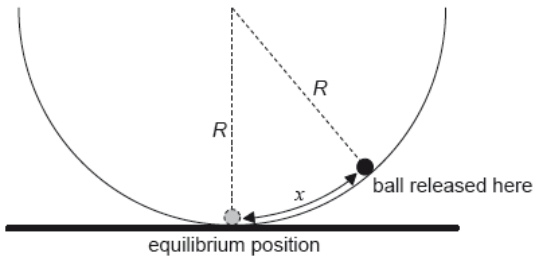
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The ball is now displaced through a small distance x from the bottom of the bowl and is then released from rest.



The magnitude of the force on the ball towards the equilibrium position is given by

$$\frac{mgx}{R}$$

where R is the radius of the bowl.

31f. Outline why the ball will perform simple harmonic oscillations about the equilibrium position. [1 mark]

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31g. Show that the period of oscillation of the ball is about 6 s.

[2 marks]

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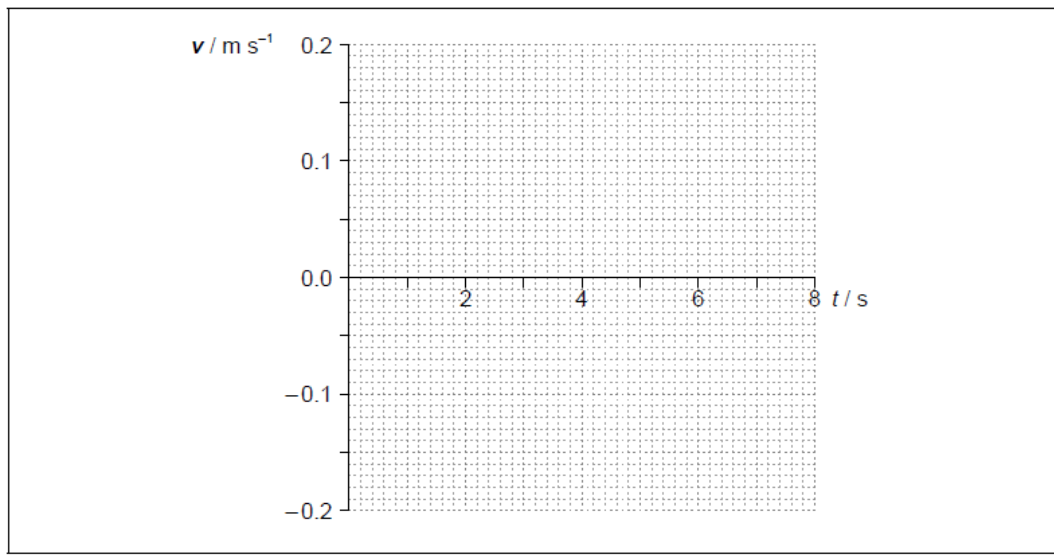
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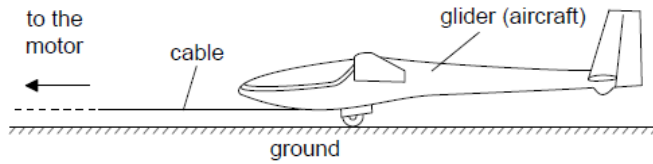
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31h. The amplitude of oscillation is 0.12 m. On the axes, draw a graph to show the variation [3 marks]
with time t of the velocity v of the ball during one period.



A glider is an aircraft with no engine. To be launched, a glider is uniformly accelerated from rest by a cable pulled by a motor that exerts a horizontal force on the glider throughout the launch.



- 32a. The glider reaches its launch speed of 27.0 m s^{-1} after accelerating for 11.0 s . Assume that the glider moves horizontally until it leaves the ground. Calculate the total distance travelled by the glider before it leaves the ground. [2 marks]

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- 32b. The glider and pilot have a total mass of 492 kg . During the acceleration the glider is subject to an average resistive force of 160 N . Determine the average tension in the cable as the glider accelerates. [3 marks]

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32c. The cable is pulled by an electric motor. The motor has an overall efficiency of 23 %. [3 marks]
Determine the average power input to the motor.

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32d. The cable is wound onto a cylinder of diameter 1.2 m. Calculate the angular velocity of [2 marks]
the cylinder at the instant when the glider has a speed of 27 m s^{-1} . Include
an appropriate unit for your answer.

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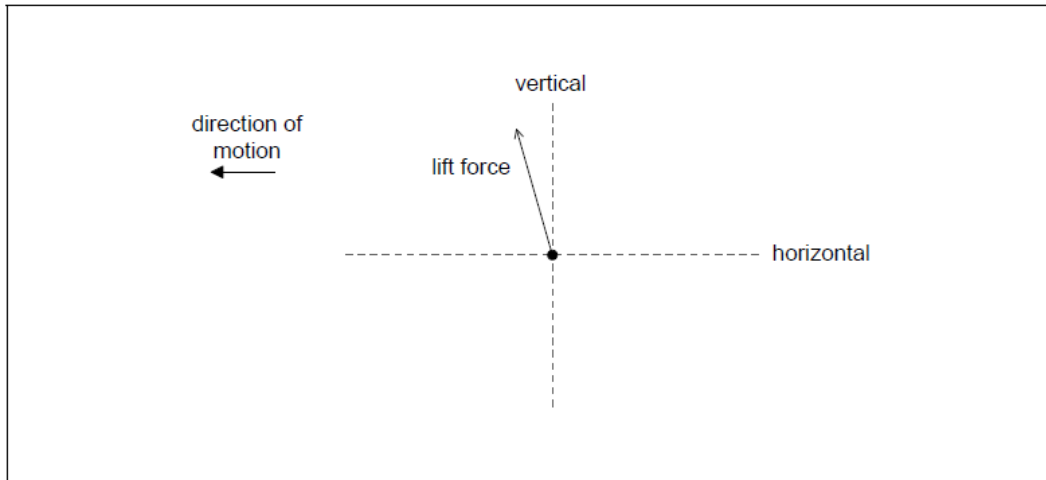
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- 32e. After takeoff the cable is released and the unpowered glider moves horizontally at constant speed. The wings of the glider provide a lift force. The diagram shows the lift force acting on the glider and the direction of motion of the glider. [2 marks]



Draw the forces acting on the glider to complete the free-body diagram. The dotted lines show the horizontal and vertical directions.

- 32f. Explain, using appropriate laws of motion, how the forces acting on the glider maintain it in level flight. [2 marks]

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- 32g. At a particular instant in the flight the glider is losing 1.00 m of vertical height for every 6.00 m that it goes forward horizontally. At this instant, the horizontal speed of the glider is 12.5 m s^{-1} . Calculate the **velocity** of the glider. Give your answer to an appropriate number of significant figures. [3 marks]

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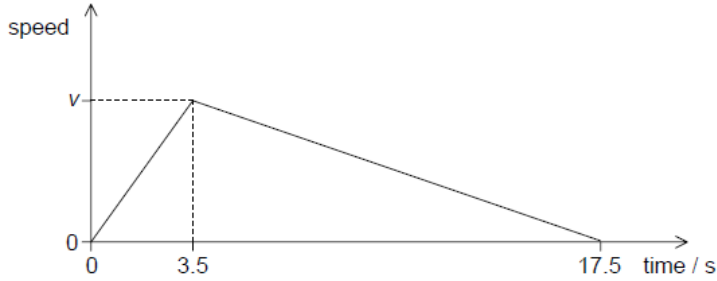
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Curling is a game played on a horizontal ice surface. A player pushes a large smooth stone across the ice for several seconds and then releases it. The stone moves until friction brings it to rest. The graph shows the variation of speed of the stone with time.



The total distance travelled by the stone in 17.5 s is 29.8 m.

33a. Determine the coefficient of dynamic friction between the stone and the ice during the last 14.0 s of the stone's motion. [3 marks]

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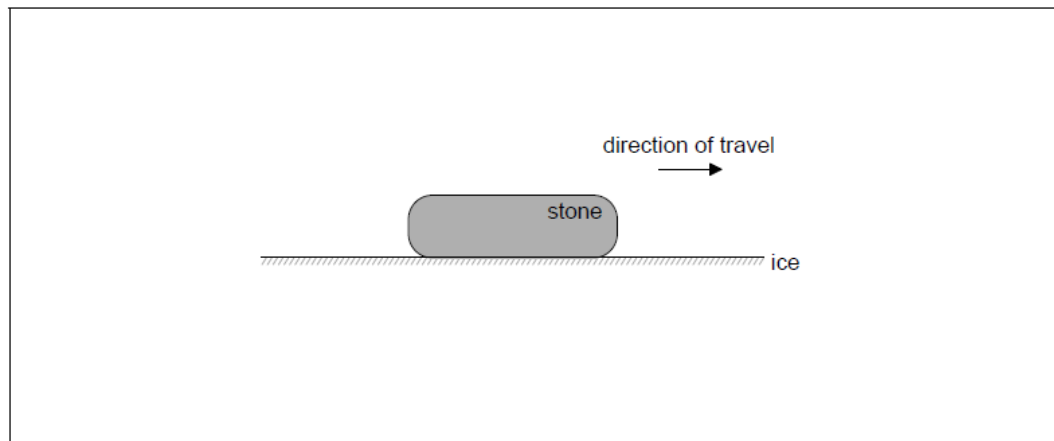
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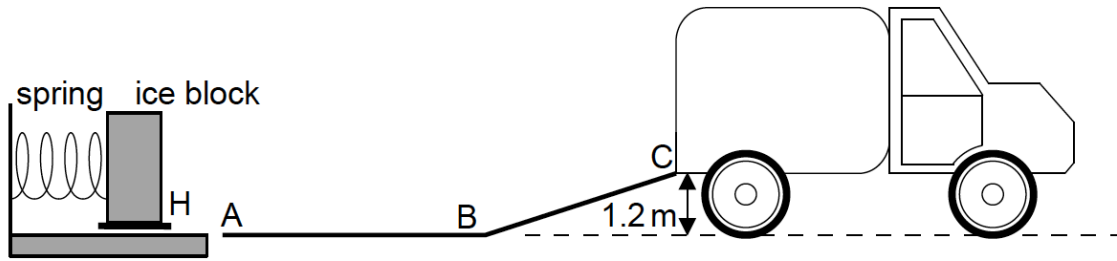
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33b. The diagram shows the stone during its motion **after** release. [3 marks]



Label the diagram to show the forces acting on the stone. Your answer should include the name, the direction **and** point of application of each force.

A company designs a spring system for loading ice blocks onto a truck. The ice block is placed in a holder H in front of the spring and an electric motor compresses the spring by pushing H to the left. When the spring is released the ice block is accelerated towards a ramp ABC. When the spring is fully decompressed, the ice block loses contact with the spring at A. The mass of the ice block is 55 kg.



Assume that the surface of the ramp is frictionless and that the masses of the spring and the holder are negligible compared to the mass of the ice block.

34a. (i) The block arrives at C with a speed of 0.90ms^{-1} . Show that the elastic energy stored in the spring is 670J. [4 marks]

(ii) Calculate the speed of the block at A.

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34b. Describe the motion of the block [3 marks]

(i) from A to B with reference to Newton's first law.

(ii) from B to C with reference to Newton's second law.

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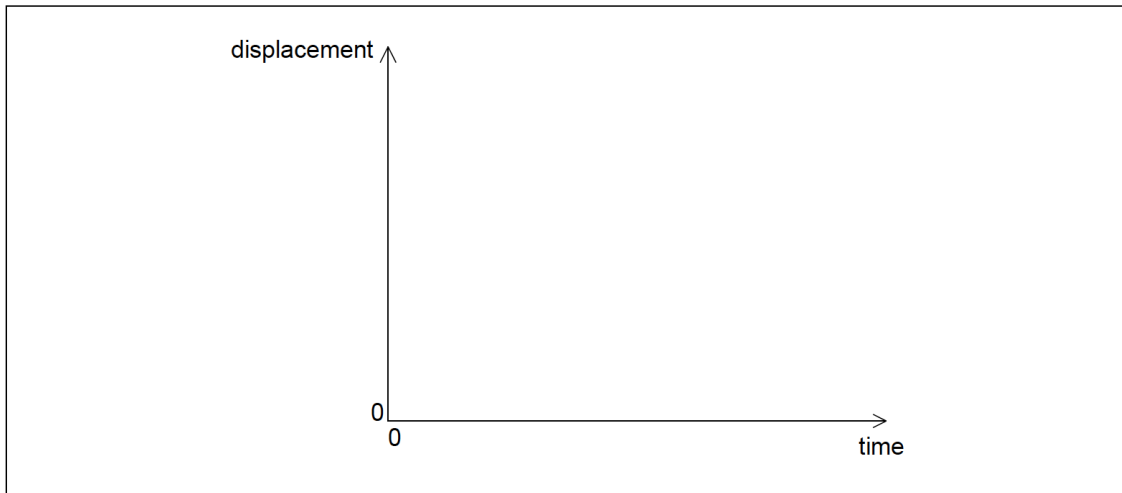
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34c. On the axes, sketch a graph to show how the displacement of the block varies with time from A to C. (You do not have to put numbers on the axes.) [2 marks]



34d. The spring decompression takes 0.42s. Determine the average force that the spring exerts on the block. [2 marks]

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34e. The electric motor is connected to a source of potential difference 120V and draws a current of 6.8A. The motor takes 1.5s to compress the spring. [2 marks]

Estimate the efficiency of the motor.

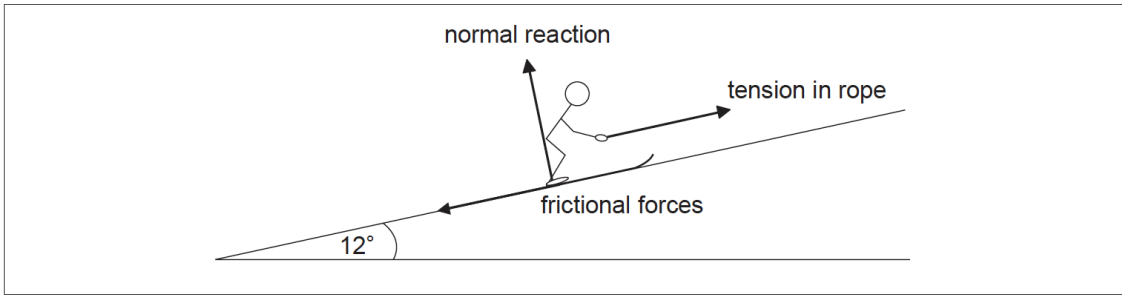
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This question is about the forces on a skier.

A skier is pulled up a hill by a rope at a steady velocity. The hill makes an angle of 12° with the horizontal. The mass of the skier and skis is 73 kg. The diagram below shows three of the forces acting on the skier.



35a. On the diagram, draw and label **one** other force acting on the skier. [1 mark]

35b. Calculate the magnitude of the normal reaction acting on the skier. [2 marks]

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35c. The total frictional force acting is 65 N. Determine the tension in the rope. [2 marks]

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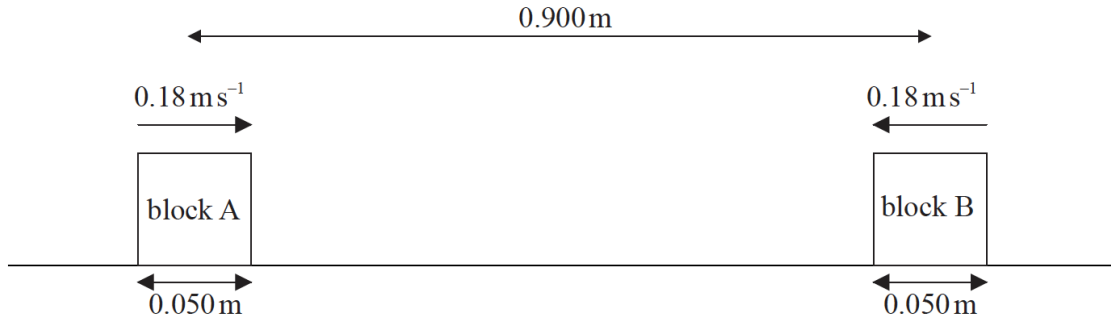
35d. Explain, using Newton's first law of motion, why the resultant force on the skier must be zero. [2 marks]

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This question is in **two** parts. **Part 1** is about a collision. **Part 2** is about electric current and resistance.

Part 1 A collision

Two identical blocks of mass 0.17kg and length 0.050m are travelling towards each other along a straight line through their centres as shown below. Assume that the surface is frictionless.



The initial distance between the centres of the blocks is 0.900m and both blocks are moving at a speed of 0.18ms^{-1} relative to the surface.

36a. Determine the time taken for the blocks to come into contact with each other. *[3 marks]*

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36b. As a result of the collision, the blocks reverse their direction of motion and travel at the [5 marks] same speed as each other. During the collision, 20% of the kinetic energy of the blocks is given off as thermal energy to the surroundings.

(i) State and explain whether the collision is elastic or inelastic.

(ii) Show that the final speed of the blocks relative to the surface is 0.16 m s^{-1} .

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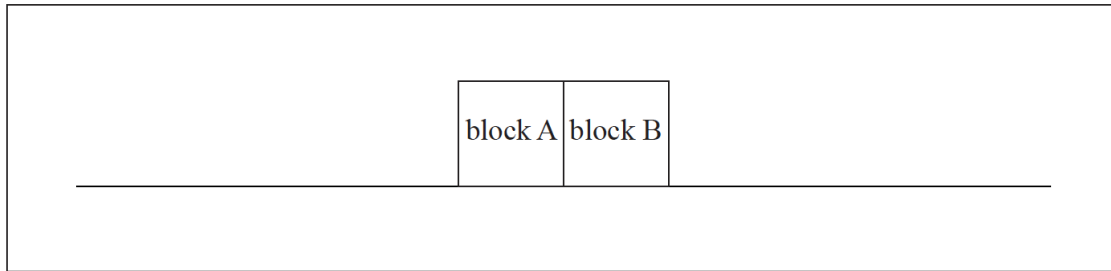
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36c. (i) State Newton's third law of motion.

[7 marks]

(ii) During the collision of the blocks, the magnitude of the force that block A exerts on block B is F_{AB} and the magnitude of the force that block B exerts on block A is F_{BA} . On the diagram below, draw labelled arrows to represent the magnitude and direction of the forces F_{AB} and F_{BA} .



(iii) The duration of the collision between the blocks is 0.070 s. Determine the average force one block exerted on the other.

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