Work, Energy and Power *[43 marks]*

1. 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

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

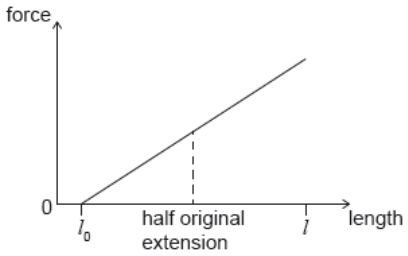
   A. $\frac{3}{4}$

   B. $\frac{4}{3}$

   C. $\frac{9}{16}$

   D. $\frac{16}{9}$

2. An increasing force acts on a metal wire and the wire extends from an initial length l_0 to 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. *[1 mark]*

   The wire then contracts to half its original extension.

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

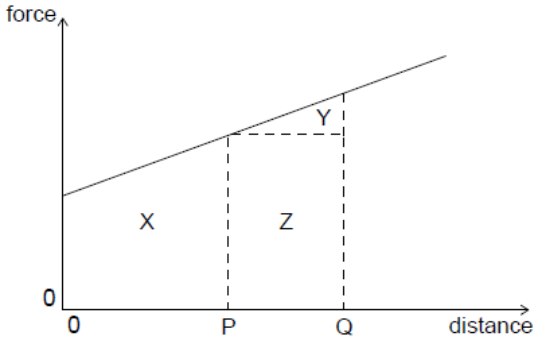
   A. 0.25 E

   B. 0.50 E

   C. 0.75 E

   D. E

3. A graph shows the variation of force acting on an object moving in a straight line with distance moved by the object. Which area represents the work done on the object during its motion from P to Q? *[1 mark]*



A. X
B. Y
C. Y + Z
D. X + Y + Z

4. The initial kinetic energy of a block moving on a horizontal floor is 48 J. A constant frictional force acts on the block bringing it to rest over a distance of 2 m. What is the frictional force on the block? *[1 mark]*

A. 24 N

B. 48 N

C. 96 N

D. 192 N

5. A stone is falling at a constant velocity vertically down a tube filled with oil. Which of the following statements about the energy changes of the stone during its motion are correct? *[1 mark]*

I. The gain in kinetic energy is less than the loss in gravitational potential energy.
II. The sum of kinetic and gravitational potential energy of the stone is constant.
III. The work done by the force of gravity has the same magnitude as the work done by friction.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

6. An object of mass m is initially at rest. When an impulse I acts on the object its final kinetic energy is E_{K}. What is the final kinetic energy when an impulse of $2I$ acts on an object of mass $2m$ initially at rest? *[1 mark]*

A. $\frac{E_{\mathrm{K}}}{2}$

B. E_{K}

C. $2E_{\mathrm{K}}$

D. $4E_{\mathrm{K}}$

7. An object of mass m_1 has a kinetic energy E_1. Another object has a mass m_2 and kinetic energy E_2. The objects have the same momentum. What is the ratio $\frac{E_1}{E_2}$? *[1 mark]*

A. 1

B. $\sqrt{\frac{m_2}{m_1}}$

C. $\frac{m_2}{m_1}$

D. $\left(\frac{m_2}{m_1}\right)^2$

8. In an inelastic collision *[1 mark]*

A. momentum and kinetic energy are both conserved.
B. momentum is conserved but kinetic energy is not.
C. kinetic energy is conserved but momentum is not.
D. neither momentum nor kinetic energy are conserved.

9. 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%

10. A car travelling at a constant velocity covers a distance of 100 m in 5.0 s. The thrust of the engine is 1.5 kN. What is the power of the car? *[1 mark]*

A. 0.75 kW
B. 3.0 kW
C. 7.5 kW
D. 30 kW

11. The efficiency of an electric motor is 20 %. When lifting a body 500 J of energy are wasted. What is the useful work done by the motor? *[1 mark]*

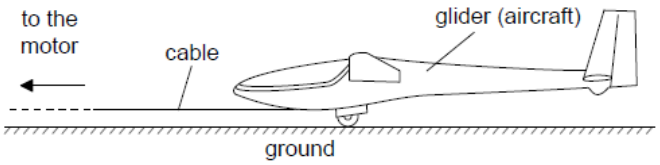
A. 100 J

B. 125 J

C. 250 J

D. 400 J

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.



12a. 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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12b. 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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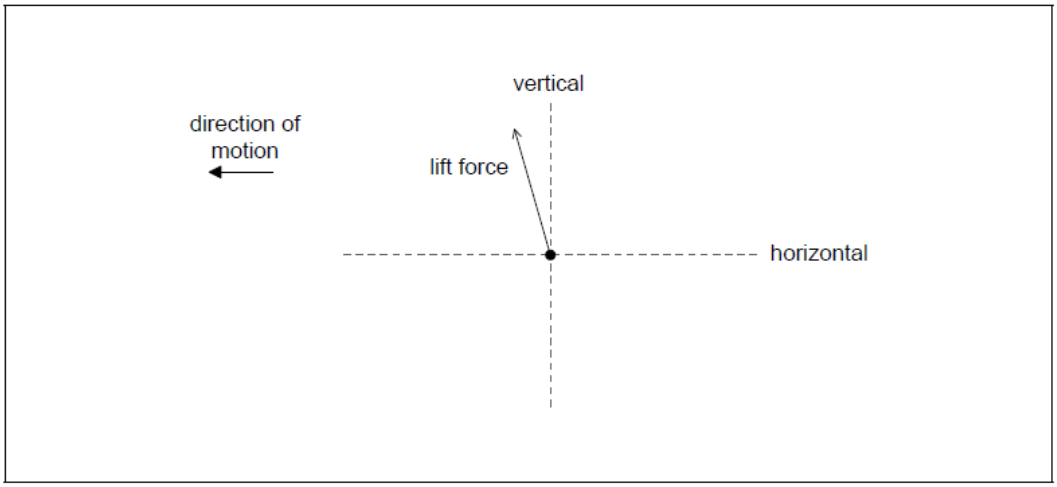
12c. The cable is pulled by an electric motor. The motor has an overall efficiency of 23 %. *[3 marks]*
Determine the average power input to the motor.

12d. 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.

12e. 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.

12f. Explain, using appropriate laws of motion, how the forces acting on the glider maintain it in level flight. *[2 marks]*

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12g. 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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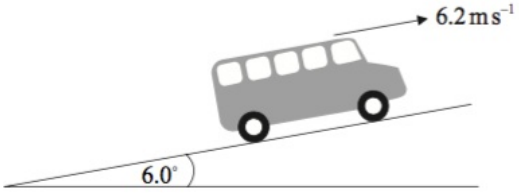
This question is in **two** parts. **Part 1** is about power and efficiency. **Part 2** is about electrical resistance.

Part 1 Power and efficiency

A bus is travelling at a constant speed of 6.2 m s $^{-1}$ along a section of road that is inclined at an angle of 6.0° to the horizontal.



13a. (i) The bus is represented by the black dot shown below. Draw a labelled sketch to represent the forces acting on the bus. *[5 marks]*

(ii) State the value of the rate of change of momentum of the bus.

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13b. The mass of the bus is 8.5×10^3 kg. Determine the rate of increase of gravitational potential energy of the bus. *[3 marks]*

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13c. Using your answer to (c) and the data in (b), estimate the magnitude of the resistive forces acting on the bus. *[3 marks]*

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13d. The engine of the bus suddenly stops working. *[4 marks]*

(i) Determine the magnitude of the net force opposing the motion of the bus at the instant at which the engine stops.

(ii) Discuss, with reference to the air resistance, the change in the net force as the bus slows down.

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