LONDON SCIENCE COLLEGE

Name:

Date:

WORK, ENERGY AND POWER
TEST 2

AS-Level

Mark

Grade

PHYSICS

For this paper you must have:

- Ruler
- Pencil and Rubber
- Scientific calculator, which you are expected to use when appropriate

Instructions

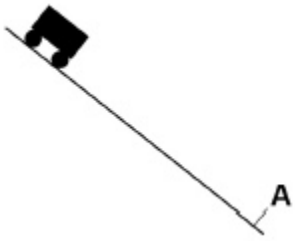
- Answer all questions
- Answer questions in the space provided
- All working must be shown

Information

- The marks for the questions are shown in brackets

1 (a) **Figure 1** shows a truck moving freely down a ramp inclined at an angle to the horizontal.

Figure 1



The truck starts from rest at the top of the ramp and reaches point **A**. Friction and air resistance are negligible.

As the truck moves down the ramp to point **A**, its centre of mass has a total vertical displacement of 8.0 m

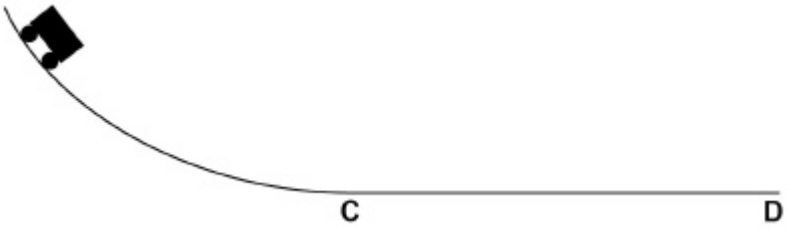
Calculate the speed of the truck at point **A**.

speed = _____ m s^{-1}

(2)

(b) **Figure 2** shows the truck moving down a ramp with a varying slope.

Figure 2



The truck starts from rest and moves freely down the ramp. It reaches point **C** and then moves along the horizontal runway to **D**. Friction and air resistance are negligible.

Discuss how the acceleration of the truck in **Figure 2** differs from the acceleration of the truck in **Figure 1**.

(3)

(c) The total vertical displacement of the centre of mass of the truck in **Figure 2** is also 8.0 m

The speed of the truck when it reaches the horizontal runway is the same as the speed of the truck in **Figure 1** when it reaches point **A**.

Explain why.

(1)

(d) The horizontal runway in **Figure 2** has negligible friction and air resistance. As the truck moves along the runway, it starts to rain. The rain falls vertically and water collects in the truck.

Discuss whether there are any changes in the momentum of the truck and collected water.

(3)

(Total 9 marks)

2 Objects **P** and **Q** are initially at rest at time $t = 0$

The same resultant force F is applied to **P** and **Q** for time T.

The mass of **P** is 10 times greater than the mass of **Q**.

What is the ratio $\frac{\text{kinetic energy of } \mathbf{P}}{\text{kinetic energy of } \mathbf{Q}}$?

A 0.1 ⬭

B 1 ⬭

C 10 ⬭

D 100 ⬭

(Total 1 mark)

3 (a) State the law of conservation of energy.

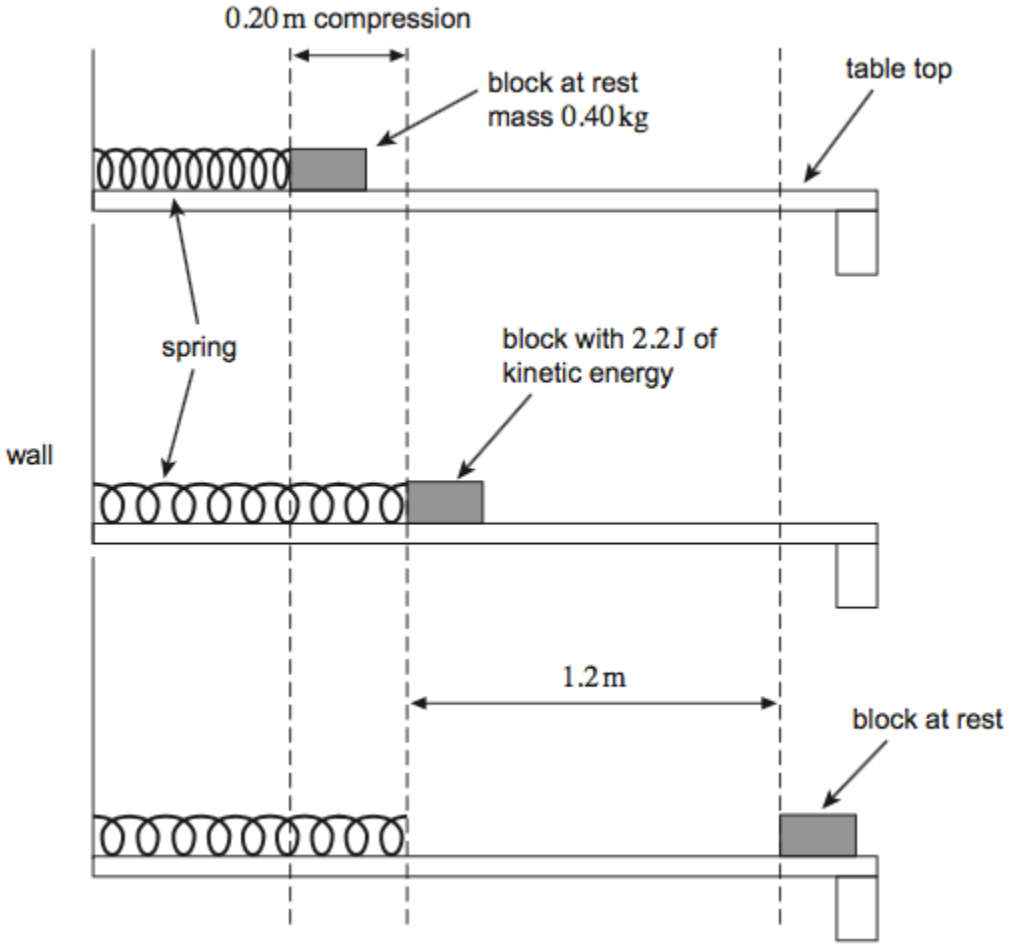
_____

_____

_____

(2)

(b) The diagram shows a block on a horizontal table top initially held against a spring so that the spring is compressed. The other end of the spring is fixed to a wall. When released the block is pushed away by the spring. When the spring reaches its natural length the block leaves the spring and then slides along the table top. A constant frictional force acting between the moving block and the table top eventually brings the block to rest.



(i) When the block leaves the spring, the block has a kinetic energy of 2.2 J. The mass of the block is 0.40 kg.
Calculate the maximum velocity of the block.

maximum velocity = _____ m s^{-1}

(1)

(ii) The block travels 1.2 m after leaving the spring before coming to rest.
Show that the frictional force between the block and the table top is about 1.8 N.

(1)

(iii) The spring was initially compressed through 0.20 m. The constant frictional force acts on the block whenever it is moving.
Calculate the elastic potential energy in the spring when in its initial compressed position.
Assume the spring has negligible mass.
State an appropriate unit for your answer.

elastic potential energy = _____ unit = _____

(3)

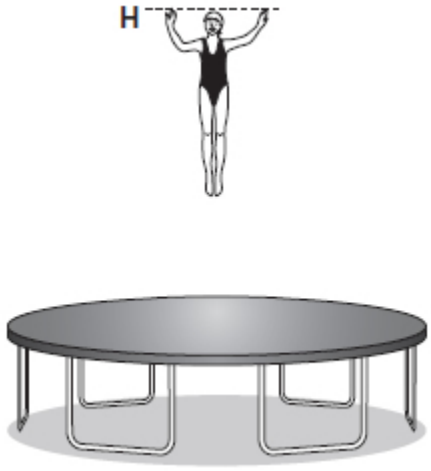
(iv) The force exerted on the block by the spring is proportional to the compression of the spring.
Calculate the maximum force exerted on the block by the spring.

maximum force = _____ N

(1)

(Total 8 marks)

4 The diagram shows a girl bouncing vertically on a trampoline. The highest point that she reaches is **H**.



Describe the energy changes involved as the girl bounces from position **H** and back to the same position shown in the diagram.

You should consider the energy losses that occur during this motion.

_____

_____

_____

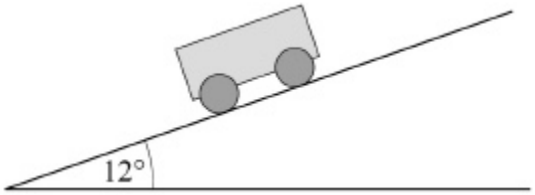
_____

_____

(Total 3 marks)

5 A car's engine produces a useful output power of 6.5×10^{4} W

The car of mass 950 kg is moving up a hill at a steady speed.
The slope of the hill is 12° to the horizontal. Resistive forces on the car are negligible.



What is the steady speed of the car?

A 7.0 m s^{-1} ⬭

B 12 m s^{-1} ⬭

C 34 m s^{-1} ⬭

D 68 m s^{-1} ⬭

(Total 1 mark)

6 An electric wheelchair, powered by a battery, allows the user to move around independently.

One type of electric wheelchair has a mass of 55 kg. The maximum distance it can travel on level ground is 12 km when carrying a user of mass 65 kg and travelling at its maximum speed of 1.5 m s^{-1}.

The battery used has an emf of 12 V and can deliver 7.2×10^{4} C as it discharges fully.

(a) Show that the average power output of the battery during the journey is about 100 W.

(3)

(b) During the journey, forces due to friction and air resistance act on the wheelchair and its user.

Assume that all the energy available in the battery is used to move the wheelchair and its user during the journey.

Calculate the total mean resistive force that acts on the wheelchair and its user.

total mean resistive force = _____ N

(2)

The diagram below shows the wheelchair and its user travelling up a hill. The hill makes an angle of 4.5° to the horizontal.

(c) Calculate the force that gravity exerts on the wheelchair and its user parallel to the slope.

force parallel to the slope = _____ N

(1)

(d) Calculate the maximum speed of the wheelchair and its user when travelling up this hill when the power output of the battery is 100 W.

Assume that the resistive forces due to friction and air resistance are the same as in part (b).

maximum speed = _____ m s^{-1}

(2)

(e) Explain how and why the maximum range of the wheelchair on level ground is affected by

- the mass of the user
- the speed at which the wheelchair travels.

Effect of mass _____

_____

_____

_____

_____

_____

Effect of speed _____

_____

_____

_____

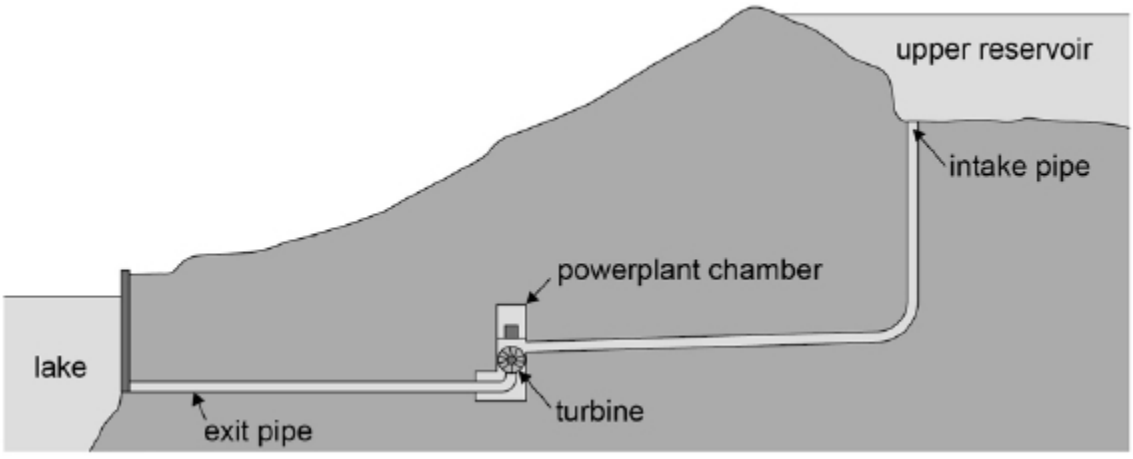
_____

_____

(4)

(Total 12 marks)

7 The diagram below shows a possible design for a pumped storage system used to generate electricity.



Water from the upper reservoir is to fall through a vertical distance of 90 m before reaching a powerplant chamber. The water rotates a turbine in the chamber that drives an electricity generator. After leaving the turbine, the water travels through an exit pipe to a lake.

(a) Show that the maximum possible speed of the water as it arrives at the turbine is about 40 m s^{-1}.

(2)

(b) The volume of water flowing into the turbine every second is 3.5 m^3.

Estimate the radius of the intake pipe that is required for the system.

pipe radius = _____ m

(2)

(c) The water leaves the powerplant chamber at a speed of 12 m s^{-1}.

Calculate the maximum possible power output of the turbine and generator.
Give an appropriate unit for your answer.

density of water = 1000 kg m^{-3}

Maximum power output = _____ unit = _____

(4)

(d) Energy losses are estimated to reduce the output power for the turbine and generator to 60% of the value you calculated in part **(c)**.

Explain **two** possible reasons for this energy loss.

1. _____

_____

_____

2. _____

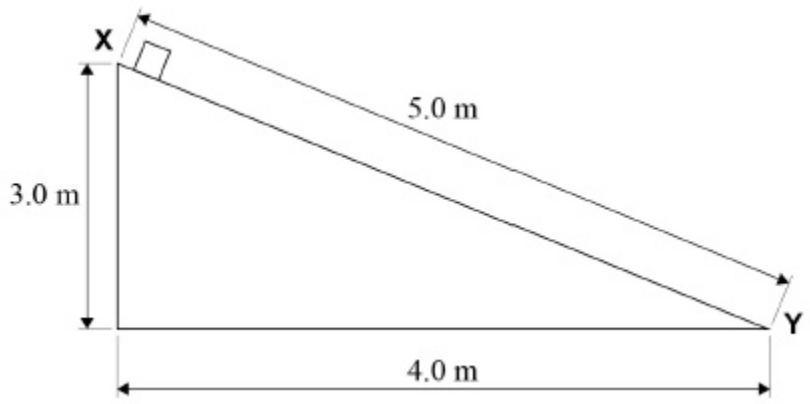
_____

_____

(2)

(Total 10 marks)

8 A mass of 2.5 kg is released from rest at **X** and slides down a ramp, of height 3.0 m, to point **Y** as shown.



When the mass reaches **Y** at the bottom of the ramp it has a velocity of 5.0 m s^{-1}.

What is the average frictional force between the mass and the ramp?

A 8.5 N ⬭

B 10.6 N ⬭

C 14.7 N ⬭

D 24.5 N ⬭

(Total 1 mark)

9 Which of the following is **not** a unit of power?

A $N\ m\ s^{-1}$ ⬭

B $kg\ m^2\ s^{-3}$ ⬭

C $J\ s^{-1}$ ⬭

D $kg\ m^{-1}\ s^{-1}$ ⬭

(Total 1 mark)

10 A firework rocket is fired vertically into the air and explodes at its highest point. What are the changes to the total kinetic energy of the rocket and the total momentum of the rocket as a result of the explosion?

	total kinetic energy of rocket	**total momentum of rocket**	
A	unchanged	unchanged	⬭
B	unchanged	increased	⬭
C	increased	unchanged	⬭
D	increased	increased	⬭

(Total 1 mark)

11 A car exerts a driving force of 500 N when travelling at a constant speed of $72\ km\ h^{-1}$ on a level track. What is the work done in 5 minutes?

A $3.0 \times 10^6\ J$ ⬭

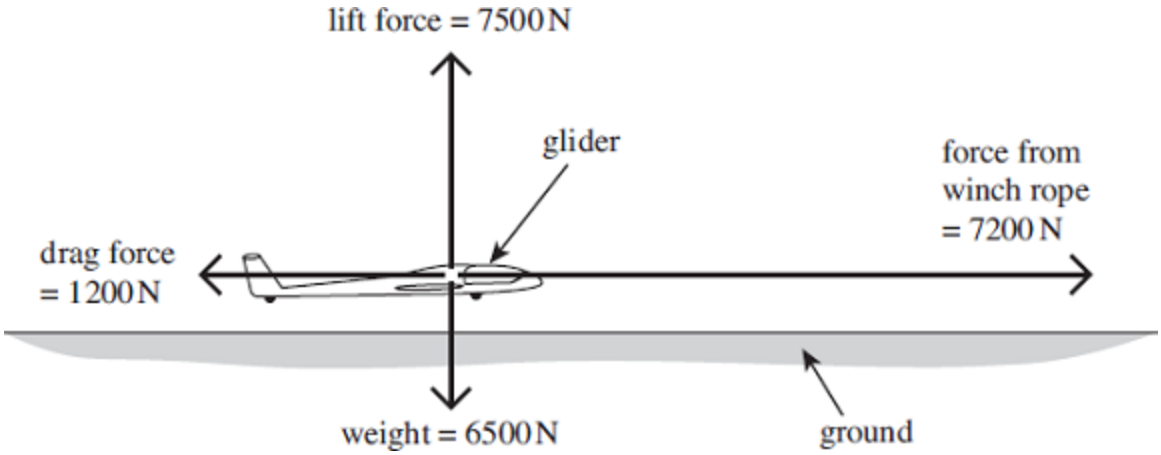
B $2.0 \times 10^6\ J$ ⬭

C $2.0 \times 10^5\ J$ ⬭

D $1.1 \times 10^5\ J$ ⬭

(Total 1 mark)

12 Gliders can be launched with a winch situated on the ground. The winch pulls a rope that is attached to the glider. The diagram below shows the forces acting on the glider at one instant during the launch.



(a) The combined weight of the glider and pilot is 6500 N.

(i) Show that the magnitude of the resultant force acting on the glider is about 6100 N.

(2)

(ii) Calculate the angle between this resultant force and the horizontal.

angle _____ degrees

(2)

(iii) Calculate the resultant acceleration of the glider in the diagram above.

resultant acceleration _____ m s^{-2}

(2)

(b) The glider climbs a vertical distance of 600 m in 55 s. The average power input to the winch motor during the launch is 320 kW.

(i) Calculate the gain in gravitational potential energy (gpe) of the glider.

gain in gpe _____ J

(2)

(ii) Calculate the percentage efficiency of the winch system used to launch the glider. Assume the kinetic energy of the glider after the launch is negligible.

efficiency _____ %

(3)

(Total 11 marks)