

**Physics**  
**Standard level**  
**Paper 2**

Monday 15 May 2017 (afternoon)

Candidate session number

1 hour 15 minutes

--	--	--	--	--	--	--	--	--	--

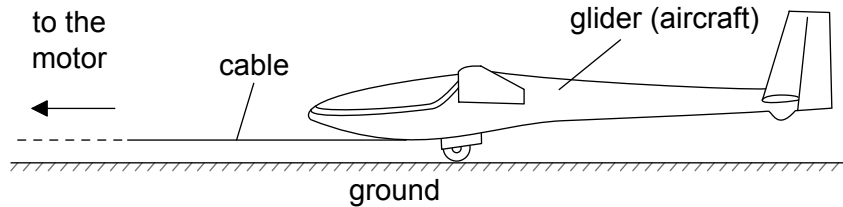
**Instructions to candidates**

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- A clean copy of the **physics data booklet** is required for this paper.
- The maximum mark for this examination paper is **[50 marks]**.



Answer **all** questions. Answers must be written within the answer boxes provided.

- 1. 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.



- (a) The glider reaches its launch speed of  $27.0 \text{ m s}^{-1}$  after accelerating for  $11.0 \text{ s}$ . 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]

.....

.....

.....

.....

- (b) The glider and pilot have a total mass of  $492 \text{ kg}$ . During the acceleration the glider is subject to an average resistive force of  $160 \text{ N}$ . Determine the average tension in the cable as the glider accelerates. [3]

.....

.....

.....

.....

.....

(This question continues on the following page)



**(Question 1 continued)**

- (c) The cable is pulled by an electric motor. The motor has an overall efficiency of 23%. Determine the average power input to the motor.

[3]

.....

.....

.....

.....

.....

.....

.....

.....

- (d) The cable is wound onto a cylinder of diameter 1.2 m. Calculate the angular velocity of the cylinder at the instant when the glider has a speed of  $27 \text{ m s}^{-1}$ . Include an appropriate unit for your answer.

[2]

.....

.....

.....

.....

**(This question continues on the following page)**

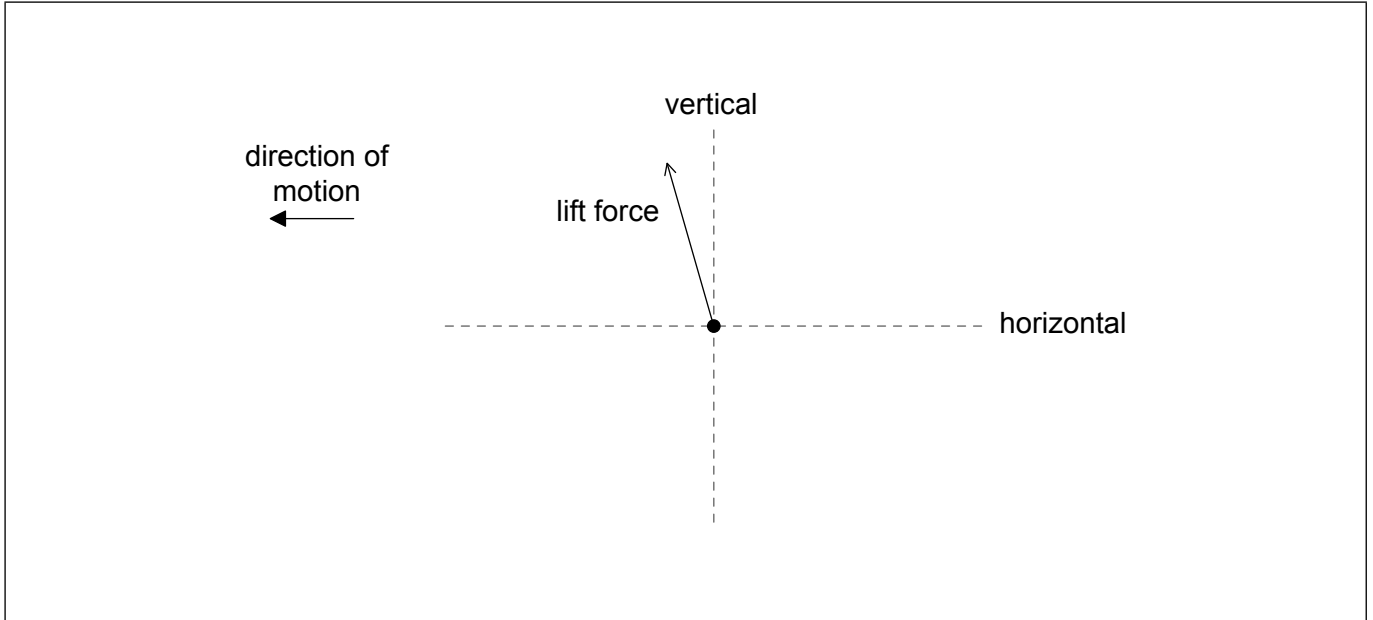


16EP03

**Turn over**

**(Question 1 continued)**

- (e) 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.



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

[2]

- (f) Explain, using appropriate laws of motion, how the forces acting on the glider maintain it in level flight.

[2]

.....  
.....  
.....  
.....

**(This question continues on the following page)**



**(Question 1 continued)**

- (g) 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  $12.5 \text{ m s}^{-1}$ . Calculate the **velocity** of the glider. Give your answer to an appropriate number of significant figures. [3]

.....

.....

.....

.....

.....

.....



16EP05

Turn over

2. (a) Outline, with reference to energy changes, the operation of a pumped storage hydroelectric system. [2]

.....

.....

.....

.....

.....

.....

- (b) The hydroelectric system has four 250 MW generators. The specific energy available from the water is  $2.7 \text{ kJ kg}^{-1}$ . Determine the maximum time for which the hydroelectric system can maintain full output when a mass of  $1.5 \times 10^{10} \text{ kg}$  of water passes through the turbines. [2]

.....

.....

.....

.....

.....

.....

- (c) Not all the stored energy can be retrieved because of energy losses in the system. Explain **one** such loss. [1]

.....

.....

.....

(This question continues on the following page)



**(Question 2 continued)**

- (d) At the location of the hydroelectric system, an average intensity of  $180 \text{ W m}^{-2}$  arrives at the Earth's surface from the Sun. Solar photovoltaic (PV) cells convert this solar energy with an efficiency of 22%. The solar cells are to be arranged in a square array. Determine the length of **one** side of the array that would be required to replace the hydroelectric system.

[2]

.....

.....

.....

.....

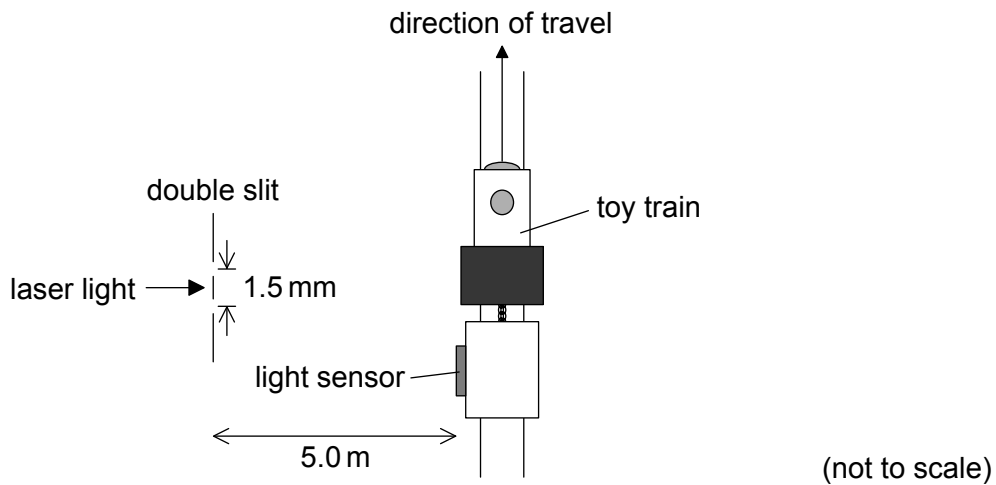
.....



16EP07

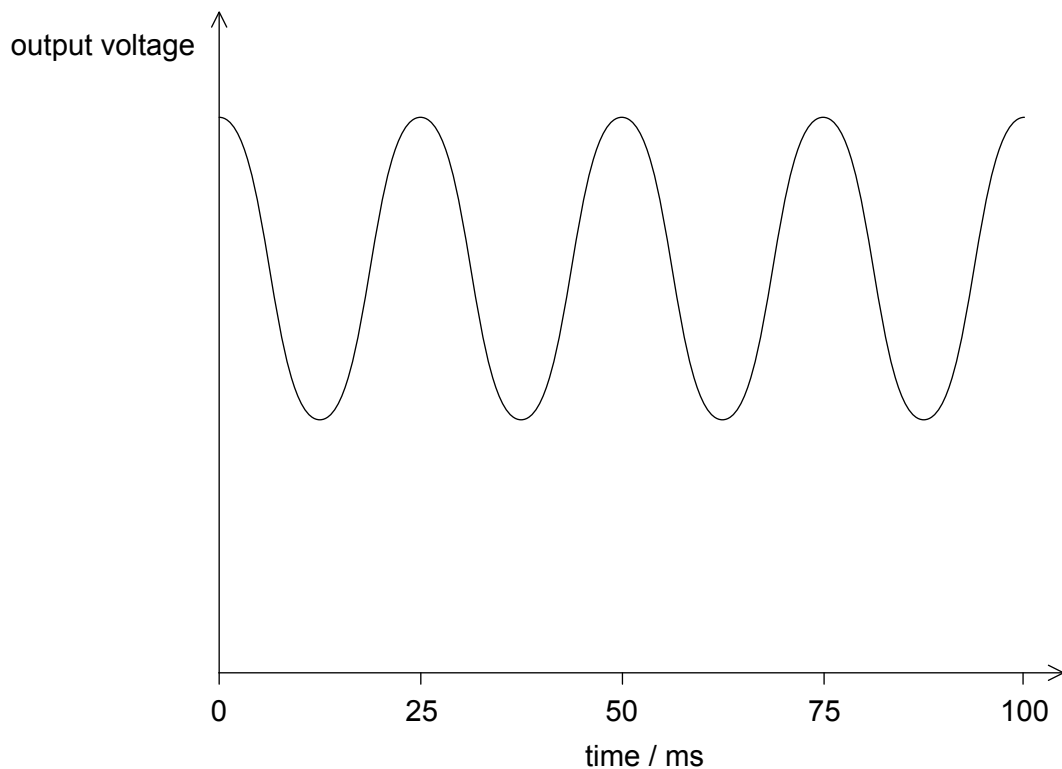
Turn over

3. A student investigates how light can be used to measure the speed of a toy train.



Light from a laser is incident on a double slit. The light from the slits is detected by a light sensor attached to the train.

The graph shows the variation with time of the output voltage from the light sensor as the train moves parallel to the slits. The output voltage is proportional to the intensity of light incident on the sensor.



(This question continues on the following page)



16EP08



**(Question 3 continued)**

- (a) Explain, with reference to the light passing through the slits, why a series of voltage peaks occurs. [3]

.....  
.....  
.....  
.....  
.....  
.....

- (b) (i) The slits are separated by 1.5 mm and the laser light has a wavelength of  $6.3 \times 10^{-7}$  m. The slits are 5.0 m from the train track. Calculate the separation between two adjacent positions of the train when the output voltage is at a maximum. [1]

.....  
.....

- (ii) Estimate the speed of the train. [2]

.....  
.....  
.....  
.....

**(This question continues on page 11)**



Please **do not** write on this page.

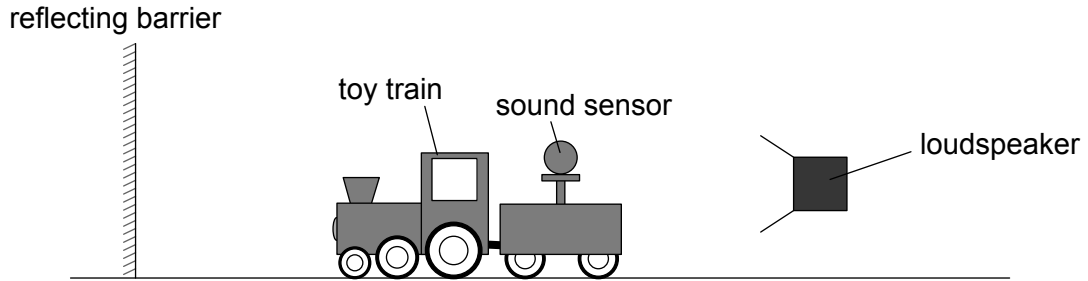
Answers written on this page will not  
be marked.



16EP10

**(Question 3 continued from page 9)**

- (c) In another experiment the student replaces the light sensor with a sound sensor. The train travels away from a loudspeaker that is emitting sound waves of constant amplitude and frequency towards a reflecting barrier.



The sound sensor gives a graph of the variation of output voltage with time along the track that is similar in shape to the graph on page 8. Explain how this effect arises.

[2]

.....

.....

.....

.....

.....

.....

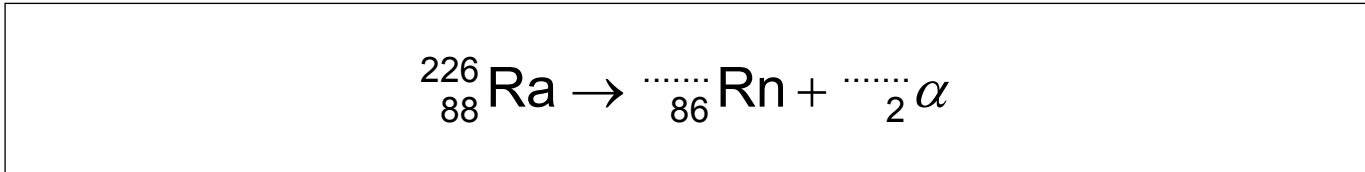


16EP11

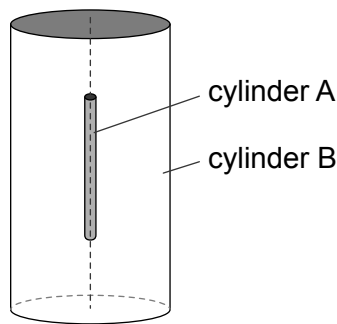
Turn over

4. The first scientists to identify alpha particles by a direct method were Rutherford and Royds. They knew that radium-226 ( $^{226}_{88}\text{Ra}$ ) decays by alpha emission to form a nuclide known as radon (Rn).

(a) Write down the missing values in the nuclear equation for this decay. [1]



(b) Rutherford and Royds put some pure radium-226 in a small closed cylinder A. Cylinder A is fixed in the centre of a larger closed cylinder B.



At the start of the experiment all the air was removed from cylinder B. The alpha particles combined with electrons as they moved through the wall of cylinder A to form helium gas in cylinder B.

The wall of cylinder A is made from glass. Outline why this glass wall had to be very thin. [1]

.....

.....

.....

.....

(This question continues on the following page)



**(Question 4 continued)**

- (c) Rutherford and Royds expected  $2.7 \times 10^{15}$  alpha particles to be emitted during the experiment. The experiment was carried out at a temperature of  $18^\circ\text{C}$ . The volume of cylinder B was  $1.3 \times 10^{-5} \text{ m}^3$  and the volume of cylinder A was negligible. Calculate the pressure of the helium gas that was collected in cylinder B. [3]

.....

.....

.....

.....

.....

.....

- (d) Rutherford and Royds identified the helium gas in cylinder B by observing its emission spectrum. Outline, with reference to atomic energy levels, how an emission spectrum is formed. [3]

.....

.....

.....

.....

.....

.....

.....

.....

- (e) The work was first reported in a peer-reviewed scientific journal. Outline why Rutherford and Royds chose to publish their work in this way. [1]

.....

.....

.....

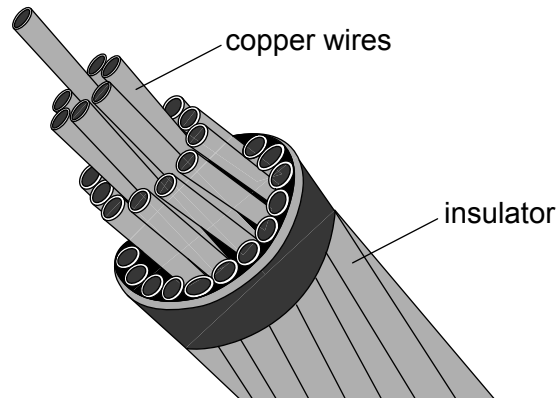
.....



16EP13

Turn over

5. A cable consisting of many copper wires is used to transfer electrical energy from a generator to an electrical load. The copper wires are protected by an insulator.



- (a) The copper wires and insulator are both exposed to an electric field. Discuss, with reference to charge carriers, why there is a significant electric current only in the copper wires.

[3]

.....

.....

.....

.....

.....

.....

(This question continues on the following page)



**(Question 5 continued)**

(b) The cable consists of 32 copper wires each of length 35 km. Each wire has a resistance of  $64\Omega$ . The resistivity of copper is  $1.7 \times 10^{-8} \Omega \text{ m}$ .

(i) Calculate the radius of each **wire**. [2]

.....  
.....  
.....  
.....

(ii) There is a current of 730 A in the cable. Show that the power loss in 1 m of the cable is about 30 W. [2]

.....  
.....  
.....  
.....

(iii) When the current is switched on in the cable the initial rate of rise of temperature of the cable is  $35 \text{ mK s}^{-1}$ . The specific heat capacity of copper is  $390 \text{ J kg}^{-1} \text{ K}^{-1}$ . Determine the mass of a length of one metre of the cable. [2]

.....  
.....  
.....  
.....



Please **do not** write on this page.

Answers written on this page  
will not be marked.



16EP16