Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Standard level
Paper 2

Friday 17 May 2019 (afternoon)

1 hour 15 minutes

Candidate session number

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]**.

2219 – 6511

12 pages

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

1. A girl rides a bicycle that is powered by an electric motor. A battery transfers energy to the electric motor. The emf of the battery is 16 V and it can deliver a charge of 43 kC when discharging completely from a full charge.

(a) The maximum speed of the girl on a horizontal road is 7.0 m s^{-1} with energy from the battery alone. The maximum distance that the girl can travel under these conditions is 20 km.

(i) Show that the time taken for the battery to discharge is about 3×10^3 s. [1]

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(ii) Deduce that the average power output of the battery is about 240 W. [2]

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(iii) Friction and air resistance act on the bicycle and the girl when they move. Assume that all the energy is transferred from the battery to the electric motor. Determine the total average resistive force that acts on the bicycle and the girl. [2]

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(Question 1 continued)

(b) The bicycle and the girl have a total mass of 66 kg. The girl rides up a slope that is at an angle of 3.0° to the horizontal.

(i) Calculate the component of weight for the bicycle and girl acting down the slope. [1]

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(ii) The battery continues to give an output power of 240 W. Assume that the resistive forces are the same as in (a)(iii).

Calculate the maximum speed of the bicycle and the girl up the slope. [2]

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(c) On another journey up the slope, the girl carries an additional mass. Explain whether carrying this mass will change the maximum distance that the bicycle can travel along the slope. [2]

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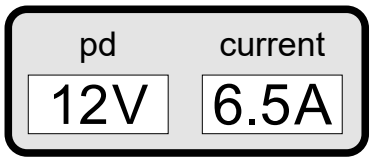
(Question 1 continued)

(d) The bicycle has a meter that displays the current and the terminal potential difference (pd) for the battery when the motor is running. The diagram shows the meter readings at one instant. The emf of the cell is 16 V.



Determine the internal resistance of the battery. [2]

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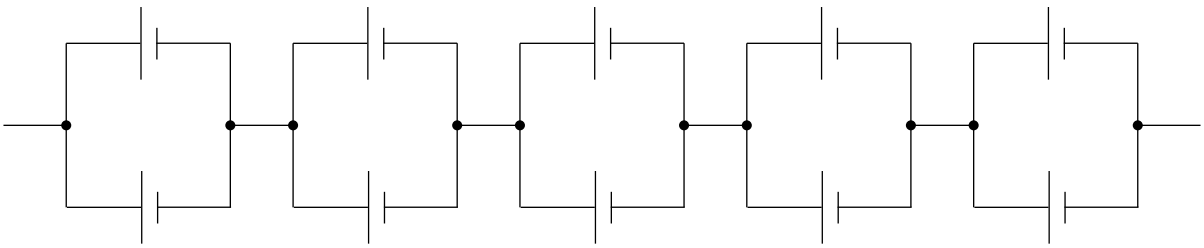
(e) The battery is made from an arrangement of 10 identical cells as shown.



Calculate

(i) the emf of **one** cell. [1]

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(ii) the internal resistance of **one** cell. [2]

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2. (a) Silicon-30 $\left({}^{30}_{14}\text{Si}\right)$ can be formed from phosphorus-30 $\left({}^{30}_{15}\text{P}\right)$ by a process of beta-plus decay.

(i) Write down the nuclear equation that represents this reaction. [2]

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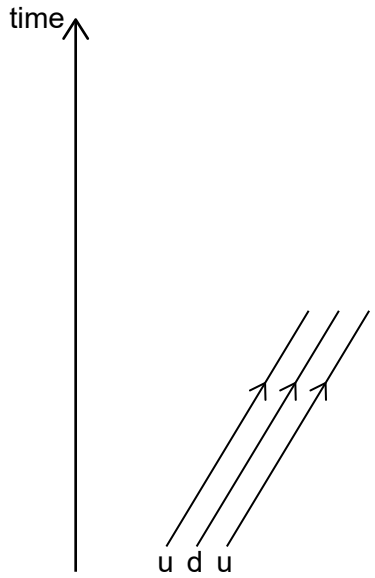
(ii) Sketch the Feynman diagram that represents this reaction. The diagram has been started for you. [3]



(iii) Energy is transferred to a hadron in an attempt to separate its quarks. Describe the implications of quark confinement for this situation. [2]

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(Question 2 continued)

(b) The Standard Model was accepted by many scientists before the observation of the Higgs boson was made.

Outline why it is important to continue research into a topic once a scientific model has been accepted by the scientific community. [1]

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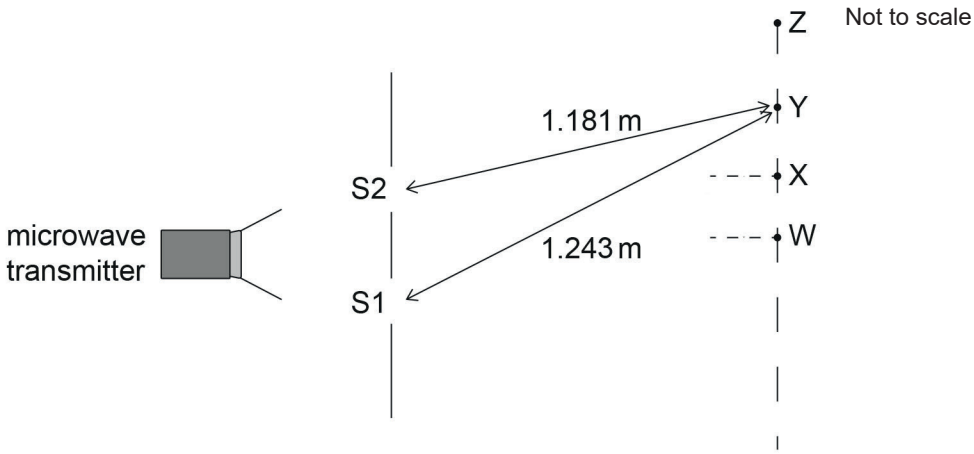
3. A beam of microwaves is incident normally on a pair of identical narrow slits S1 and S2.



When a microwave receiver is initially placed at W which is equidistant from the slits, a maximum in intensity is observed. The receiver is then moved towards Z along a line parallel to the slits. Intensity maxima are observed at X and Y with one minimum between them. W, X and Y are consecutive maxima.

(a) Explain why intensity maxima are observed at X and Y. [2]

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(Question 3 continued)

The distance from S1 to Y is 1.243 m and the distance from S2 to Y is 1.181 m.

(b) Determine the frequency of the microwaves. [3]

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(c) Outline **one** reason why the maxima observed at W, X and Y will have different intensities from each other. [1]

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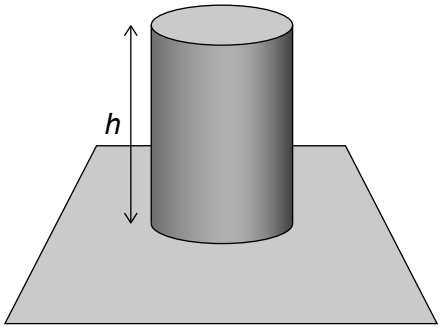
4. A solid cylinder of height h and density ρ rests on a flat surface.



(a) Show that the pressure p_C exerted by the cylinder on the surface is given by $p_C = \rho gh$. [2]

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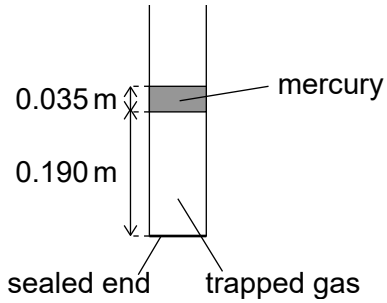
(b) A tube of constant circular cross-section, sealed at one end, contains an ideal gas trapped by a cylinder of mercury of length 0.035 m. The whole arrangement is in the Earth's atmosphere. The density of mercury is $1.36 \times 10^4\,\text{kg m}^{-3}$.



When the mercury is above the gas column the length of the gas column is 0.190 m.

(i) Show that $(p_o + p_m) \times 0.190 = \frac{nRT}{A}$ where

p_o = atmospheric pressure
p_m = pressure due to the mercury column
T = temperature of the trapped gas
n = number of moles of the trapped gas
A = cross-sectional area of the tube. [2]

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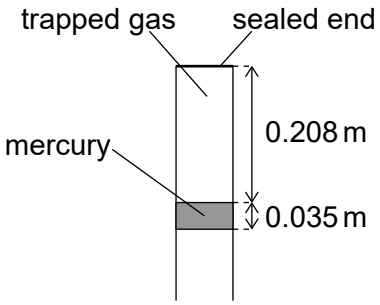
(Question 4 continued)

(ii) The tube is slowly rotated until the gas column is above the mercury.

diagram not to scale



The length of the gas column is now 0.208 m. The temperature of the trapped gas does not change during the process.

Determine the atmospheric pressure. Give a suitable unit for your answer. [4]

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(iii) Outline why the gas particles in the tube hit the mercury surface less often after the tube has been rotated. [1]

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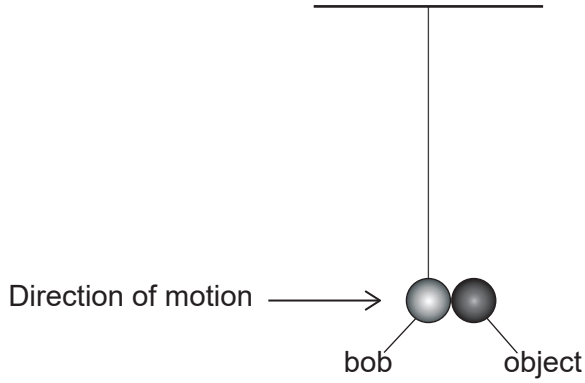
5. A small metal pendulum bob of mass 75 g is suspended at rest from a fixed point with a length of thread of negligible mass. Air resistance is negligible. The bob is then displaced to the left.

At time $t = 0$ the bob is moving horizontally to the right at $0.8\,m\,s^{-1}$. It collides with a small stationary object also of mass 75 g. Both objects then move together with motion that is simple harmonic.



(a) Calculate the speed of the combined masses immediately after the collision. [1]

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(b) Show that the collision is inelastic. [3]

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(c) Describe the changes in gravitational potential energy of the oscillating system from $t = 0$ as it oscillates through one cycle of its motion. [1]

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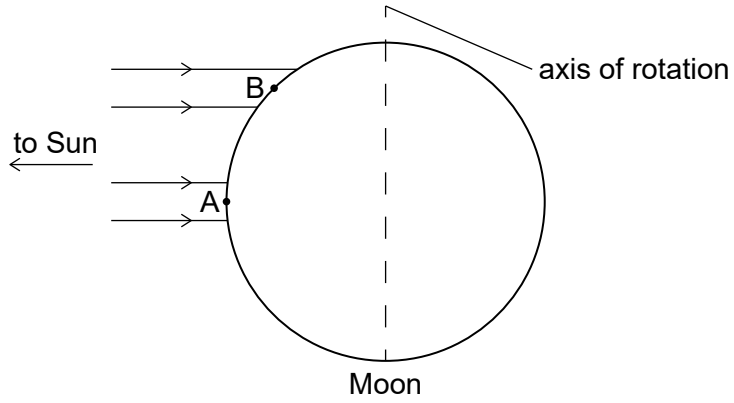
6. The Moon has no atmosphere and orbits the Earth. The diagram shows the Moon with rays of light from the Sun that are incident at 90° to the axis of rotation of the Moon.



(a) (i) A black body is on the Moon's surface at point A. Show that the maximum temperature that this body can reach is 400 K. Assume that the Earth and the Moon are the same distance from the Sun. [2]

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(ii) Another black body is on the Moon's surface at point B.

Outline, without calculation, why the maximum temperature of the black body at point B is less than at point A. [2]

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(Question 6 continued)

(b) The albedo of the Earth's atmosphere is 0.28. Outline why the maximum temperature of a black body on the Earth when the Sun is overhead is less than that at point A on the Moon. [1]

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(c) The Moon orbits the Earth in a circular path.

Outline why

(i) a force acts on the Moon. [1]

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(ii) this force does no work on the Moon. [1]

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