Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Standard level
Paper 2

Tuesday 8 November 2016 (morning)

Candidate session number

1 hour 15 minutes

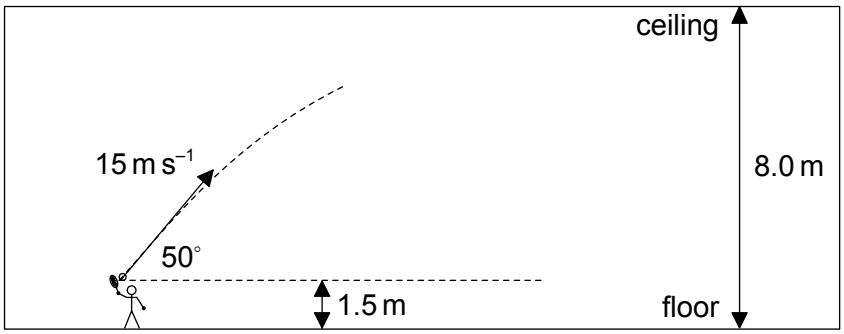
Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Write your answers in the 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]**.

8816 – 6505

Answer **all** questions. Write your answers in the boxes provided.

1. A tennis ball is hit with a racket from a point 1.5 m above the floor. The ceiling is 8.0 m above the floor. The initial velocity of the ball is 15 m s^{-1} at 50° above the horizontal. Assume that air resistance is negligible.



(a) Determine whether the ball will hit the ceiling. [3]

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(b) The tennis ball was stationary before being hit. It has a mass of 5.8×10^{-2} kg and was in contact with the racket for 23 ms.

(i) Calculate the mean force exerted by the racket on the ball. [1]

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(ii) Explain how Newton's third law applies when the racket hits the tennis ball. [2]

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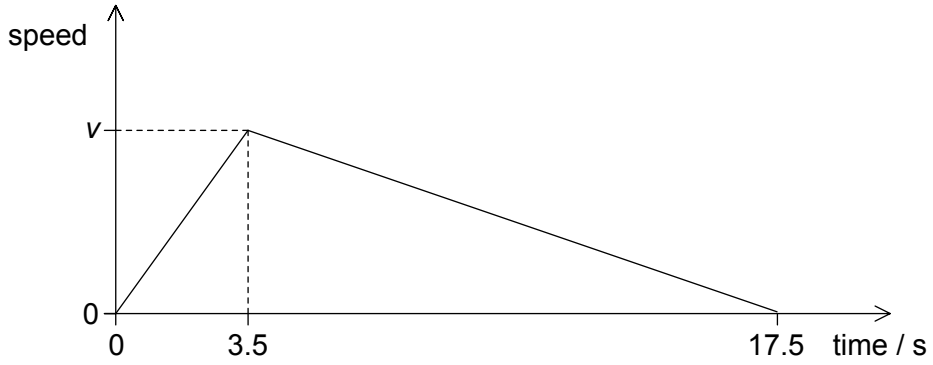
2. Curling is a game played on a horizontal ice surface. A player pushes a large smooth stone across the ice for several seconds and then releases it. The stone moves until friction brings it to rest. The graph shows the variation of speed of the stone with time.



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

(a) Determine the maximum speed v of the stone. [2]

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(b) (i) The stone has a mass of 20 kg. Determine the frictional force on the stone during the last 14.0 s. [2]

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(ii) Determine the energy dissipated due to friction during the last 14.0 s. [2]

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3. (a) Define *internal energy*. [2]

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(b) 0.46 mole of an ideal monatomic gas is trapped in a cylinder. The gas has a volume of 21 m^3 and a pressure of 1.4 Pa.

(i) State how the internal energy of an ideal gas differs from that of a real gas. [1]

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(ii) Determine, in kelvin, the temperature of the gas in the cylinder. [2]

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(iii) The kinetic theory of ideal gases is one example of a scientific model. Identify **one** reason why scientists find such models useful. [1]

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4. (a) A particular K meson has a quark structure $\bar{u}s$. State the charge on this meson. [1]

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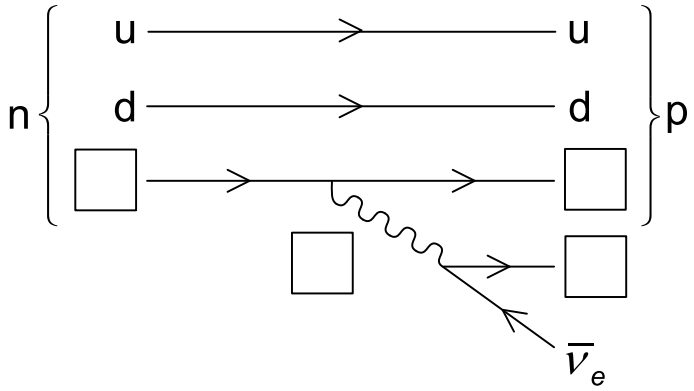
(b) The Feynman diagram shows the changes that occur during beta minus (β^-) decay.



Label the diagram by inserting the **four** missing particle symbols. [2]

(c) Carbon-14 (C-14) is a radioactive isotope which undergoes beta minus (β^-) decay to the stable isotope nitrogen-14 (N-14). Energy is released during this decay. Explain why the mass of a C-14 nucleus and the mass of a N-14 nucleus are slightly different even though they have the same nucleon number. [2]

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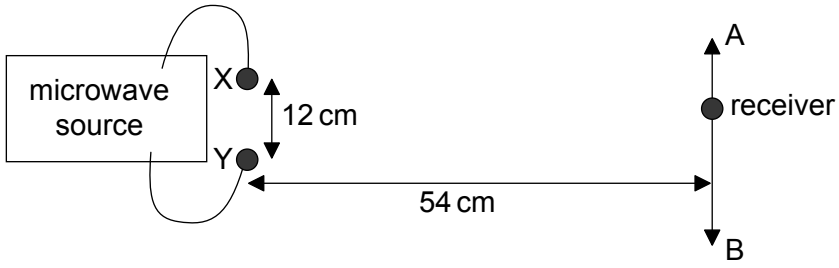
5. (a) Two microwave transmitters, X and Y, are placed 12 cm apart and are connected to the same source. A single receiver is placed 54 cm away and moves along a line AB that is parallel to the line joining X and Y.



Maxima and minima of intensity are detected at several points along AB.

(i) Explain the formation of the intensity **minima**. [2]

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(ii) The distance between the central maximum and the first minimum is 7.2 cm. Calculate the wavelength of the microwaves. [2]

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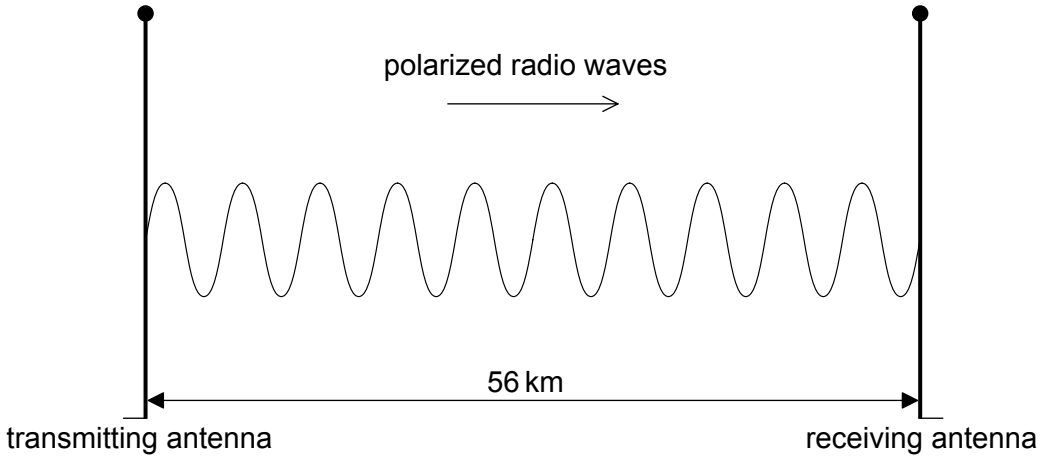
(Question 5 continued)

(b) Radio waves are emitted by a straight conducting rod antenna (aerial). The plane of polarization of these waves is parallel to the transmitting antenna.



An identical antenna is used for reception. Suggest why the receiving antenna needs to be be parallel to the transmitting antenna. [2]

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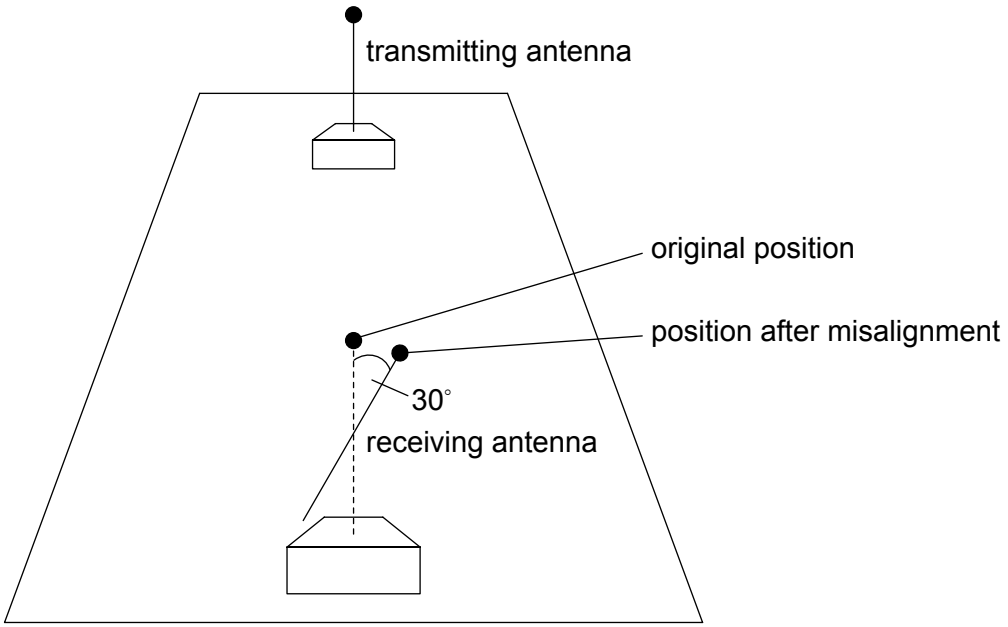
(Question 5 continued)

(c) The receiving antenna becomes misaligned by 30° to its original position.



The power of the received signal in this new position is 12 μW.

(i) Calculate the power that was received in the original position. [2]

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(ii) Calculate the minimum time between the wave leaving the transmitting antenna and its reception. [1]

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6. (a) (i) Define *gravitational field strength*. [1]

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(ii) State the SI unit for gravitational field strength. [1]

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(b) A planet orbits the Sun in a circular orbit with orbital period T and orbital radius R. The mass of the Sun is M.

(i) Show that $T = \sqrt{\frac{4\pi^2 R^3}{GM}}$. [2]

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(ii) The Earth's orbit around the Sun is almost circular with radius 1.5×10^{11} m. Estimate the mass of the Sun. [2]

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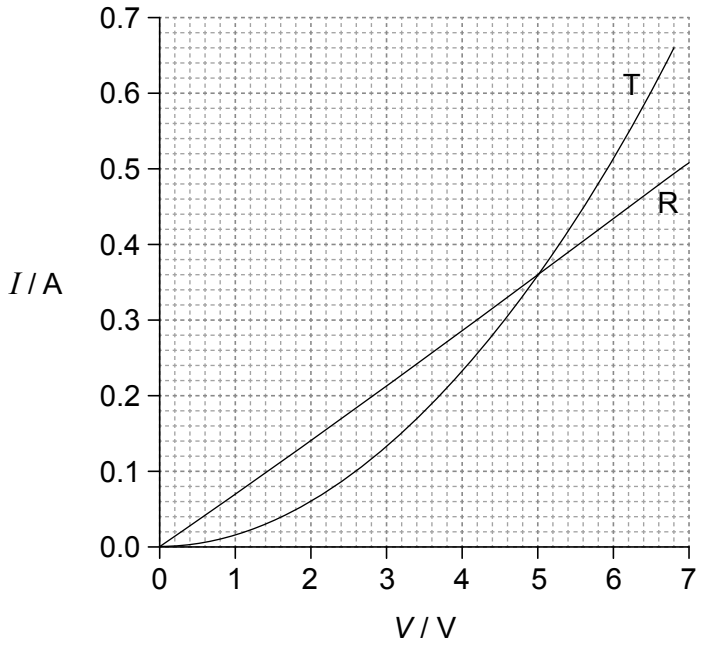
7. The graph shows how current I varies with potential difference V for a resistor R and a non-ohmic component T.



(a) (i) State how the resistance of T varies with the current going through T. [1]

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(ii) Deduce, without a numerical calculation, whether R **or** T has the greater resistance at $I = 0.40\,\text{A}$. [2]

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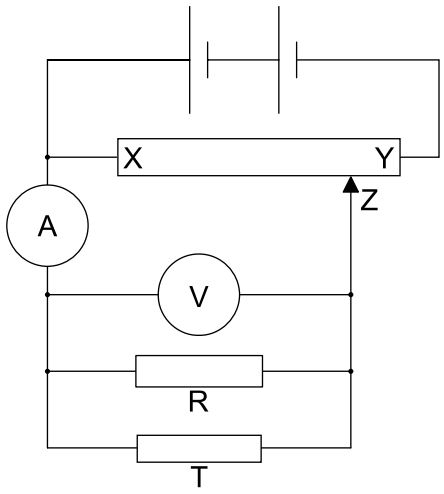
(Question 7 continued)

(b) Components R and T are placed in a circuit. Both meters are ideal.



Slider Z of the potentiometer is moved from Y to X.

(i) State what happens to the magnitude of the current in the ammeter. [1]

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(ii) Estimate, with an explanation, the voltmeter reading when the ammeter reads 0.20 A. [2]

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8. The following data are available for a natural gas power station that has a high efficiency.

Rate of consumption of natural gas	$= 14.6\,\text{kg s}^{-1}$
Specific energy of natural gas	$= 55.5\,\text{MJ kg}^{-1}$
Efficiency of electrical power generation	$= 59.0\,\%$
Mass of CO_2 generated per kg of natural gas	$= 2.75\,\text{kg}$
One year	$= 3.16 \times 10^7\,\text{s}$

(a) Calculate, with a suitable unit, the electrical power output of the power station. [1]

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(b) Calculate the mass of CO_2 generated in a year assuming the power station operates continuously. [1]

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(c) Explain, using your answer to (b), why countries are being asked to decrease their dependence on fossil fuels. [2]

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(d) Describe, in terms of energy transfers, how thermal energy of the burning gas becomes electrical energy. [2]

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