Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Standard level
Paper 2

Tuesday 30 October 2018 (afternoon)

Candidate session number

1 hour 15 minutes

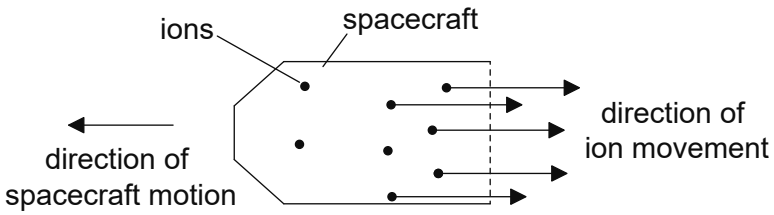
Instructions to candidates

- 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]**.

8818 – 6505

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

1. Ion-thrust engines can power spacecraft. In this type of engine, ions are created in a chamber and expelled from the spacecraft. The spacecraft is in outer space when the propulsion system is turned on. The spacecraft starts from rest.



The mass of ions ejected each second is 6.6×10^{-6} kg and the speed of each ion is 5.2×10^{4} m s^{-1}. The initial total mass of the spacecraft and its fuel is 740 kg. Assume that the ions travel away from the spacecraft parallel to its direction of motion.

(a) Determine the initial acceleration of the spacecraft. [2]

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(Question 1 continued)

(b) An initial mass of 60 kg of fuel is in the spacecraft for a journey to a planet. Half of the fuel will be required to slow down the spacecraft before arrival at the destination planet.

(i) Estimate the maximum speed of the spacecraft. [2]

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(ii) Outline why scientists sometimes use estimates in making calculations. [1]

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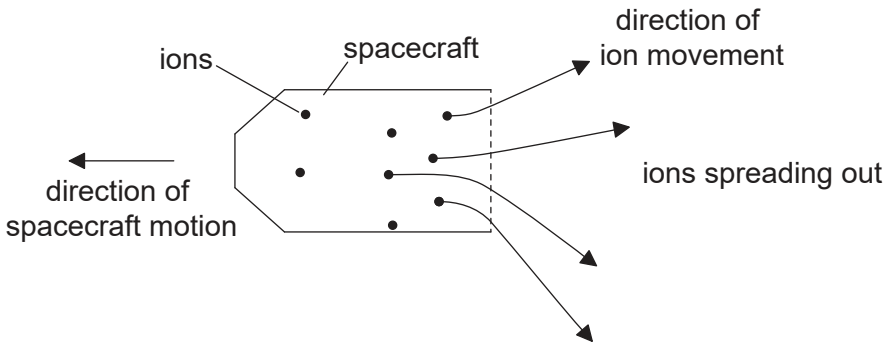
(Question 1 continued)

(c) In practice, the ions leave the spacecraft at a range of angles as shown.



(i) Outline why the ions are likely to spread out. [2]

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(ii) Explain what effect, if any, this spreading of the ions has on the acceleration of the spacecraft. [2]

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(Question 1 continued)

(d) On arrival at the planet, the spacecraft goes into orbit as it comes into the gravitational field of the planet.

(i) Outline what is meant by the gravitational field strength at a point. [2]

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(ii) Newton's law of gravitation applies to point masses. Suggest why the law can be applied to a satellite orbiting a spherical planet of uniform density. [1]

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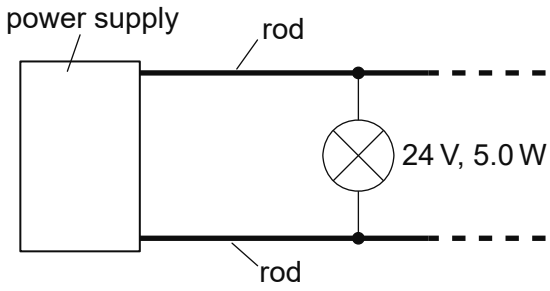
2. A lighting system consists of two long metal rods with a potential difference maintained between them. Identical lamps can be connected between the rods as required.



The following data are available for the lamps when at their working temperature.

Lamp specifications	24 V, 5.0 W
Power supply emf	24 V
Power supply maximum current	8.0 A
Length of each rod	12.5 m
Resistivity of rod metal	$7.2 \times 10^{-7}\ \Omega\,\text{m}$

(a) Each rod is to have a resistance no greater than $0.10\ \Omega$. Calculate, in m, the minimum radius of each rod. Give your answer to an appropriate number of significant figures. [3]

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(b) Calculate the maximum number of lamps that can be connected between the rods. Neglect the resistance of the rods. [2]

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(Question 2 continued)

(c) One advantage of this system is that if one lamp fails then the other lamps in the circuit remain lit. Outline **one** other electrical advantage of this system compared to one in which the lamps are connected in series. [1]

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3. A chicken's egg of mass 58 g is dropped onto grass from a height of 1.1 m. The egg comes to rest in a time of 55 ms. Assume that air resistance is negligible and that the egg does not bounce or break.

(a) Determine the magnitude of the average decelerating force that the ground exerts on the egg. [4]

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(b) Explain why the egg is likely to break when dropped onto concrete from the same height. [2]

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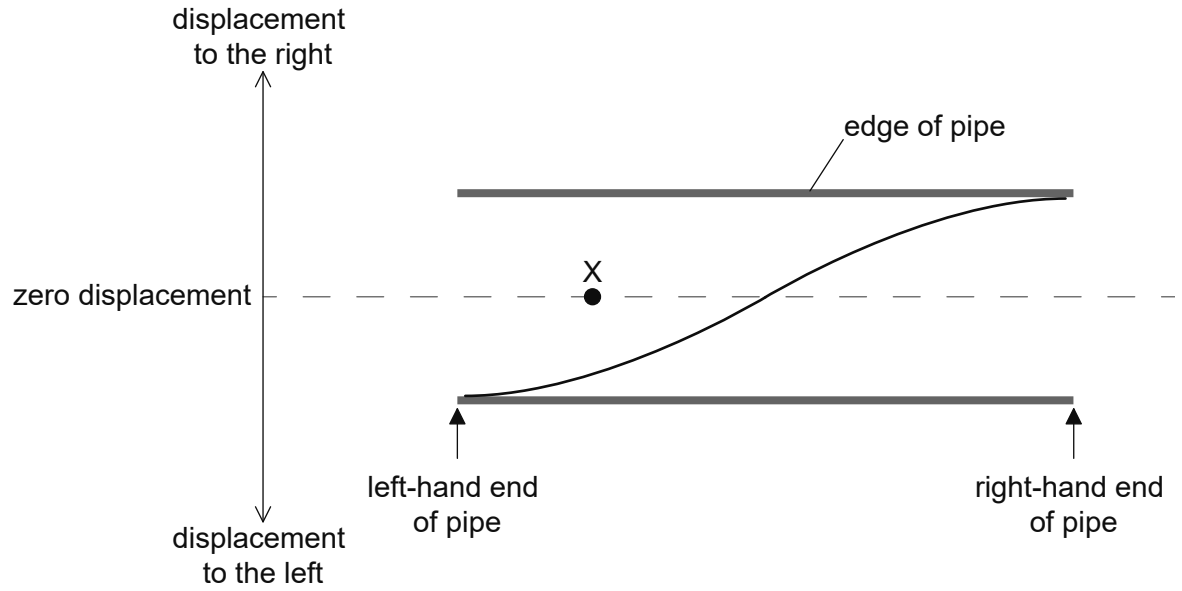
4. A pipe is open at both ends. A first-harmonic standing wave is set up in the pipe. The diagram shows the variation of displacement of air molecules in the pipe with distance along the pipe at time $t = 0$. The frequency of the first harmonic is f.



(a) An air molecule is situated at point X in the pipe at $t = 0$. Describe the motion of this air molecule during one complete cycle of the standing wave beginning from $t = 0$. [2]

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(Question 4 continued)

(b) The speed of sound c for longitudinal waves in air is given by

$$c = \sqrt{\frac{K}{\rho}}$$

where ρ is the density of the air and K is a constant.

A student measures f to be 120 Hz when the length of the pipe is 1.4 m. The density of the air in the pipe is 1.3 kg m^{-3}. Determine, in kg m^{-1} s^{-2}, the value of K for air. [3]

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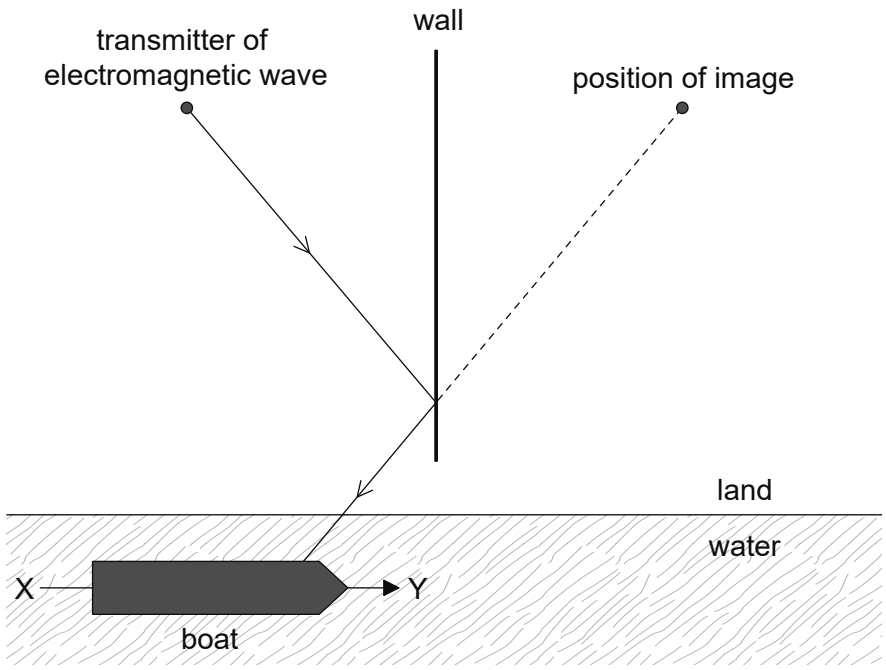
(Question 4 continued)

(c) A transmitter of electromagnetic waves is next to a long straight vertical wall that acts as a plane mirror to the waves. An observer on a boat detects the waves both directly and as an image from the other side of the wall. The diagram shows one ray from the transmitter reflected at the wall and the position of the image.

plan view **not to scale**



(i) Demonstrate, using a second ray, that the image appears to come from the position indicated. [1]

(ii) Outline why the observer detects a series of increases and decreases in the intensity of the received signal as the boat moves along the line XY. [2]

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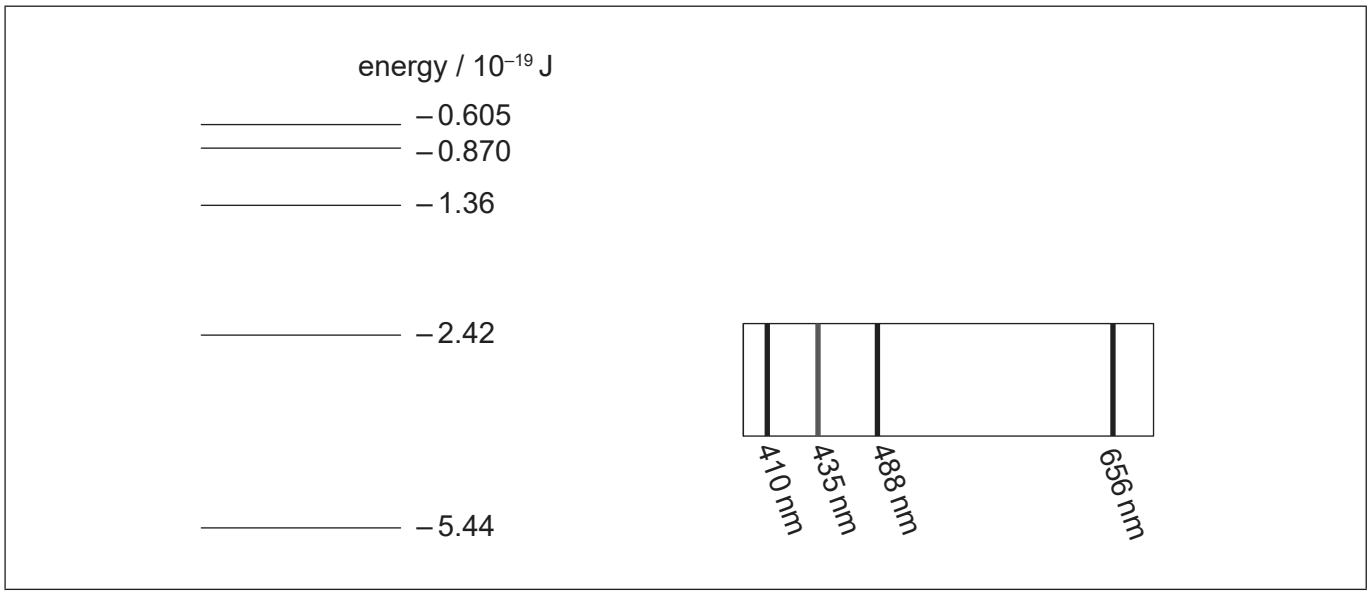
5. The diagram shows the position of the principal lines in the visible spectrum of atomic hydrogen and some of the corresponding energy levels of the hydrogen atom.



(a) Determine the energy of a photon of blue light (435nm) emitted in the hydrogen spectrum. [3]

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(b) Identify, with an arrow labelled B on the diagram, the transition in the hydrogen spectrum that gives rise to the photon with the energy in (a). [1]

(c) Explain your answer to (b). [2]

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6. The ratio $\frac{\text{distance of Mars from the Sun}}{\text{distance of Earth from the Sun}} = 1.5$.

(a) Show that the intensity of solar radiation at the orbit of Mars is about 600 W m^{-2}. [2]

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(b) Determine, in K, the mean surface temperature of Mars. Assume that Mars acts as a black body. [2]

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(c) The atmosphere of Mars is composed mainly of carbon dioxide and has a pressure less than 1 % of that on the Earth. Outline why the greenhouse effect is not significant on Mars. [2]

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7. Liquid oxygen at its boiling point is stored in an insulated tank. Gaseous oxygen is produced from the tank when required using an electrical heater placed in the liquid.

The following data are available.

Mass of 1.0 mol of oxygen $= 32$ g
Specific latent heat of vaporization of oxygen $= 2.1 \times 10^5$ J kg^{-1}

(a) Distinguish between the internal energy of the oxygen at the boiling point when it is in its liquid phase and when it is in its gas phase. [2]

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(b) An oxygen flow rate of 0.25 mol s^{-1} is needed.

(i) Calculate, in kW, the heater power required. [2]

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(ii) Calculate the volume of the oxygen produced in one second when it is allowed to expand to a pressure of 0.11 MPa and to reach a temperature of 260 K. [1]

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(Question 7 continued)

(c) State **one** assumption of the kinetic model of an ideal gas that does not apply to oxygen. [1]

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