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Physics
Higher level
Paper 2

29 April 2026

Zone A morning | **Zone B** morning | **Zone C** morning

Session number

2 hours 30 minutes

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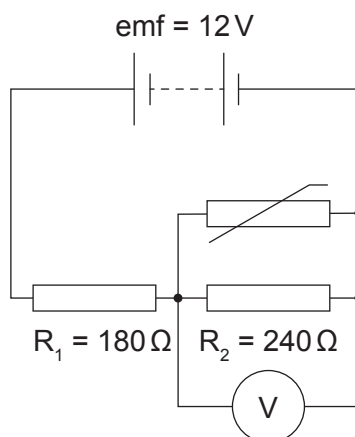
Instructions to students

- 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 **[90 marks]**.



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

1. A battery of emf 12V and negligible internal resistance is connected to two resistors and a thermistor as shown.



(This question continues on the following page)



(Question 1 continued)

(a) At a particular temperature the reading of the voltmeter is 3.0 V.

(i) Show that, at this temperature, the current in the battery is 50 mA. [2]

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(ii) Calculate the resistance of the thermistor. [2]

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(b) The resistance of the thermistor decreases when the temperature increases. State and explain what happens to the voltmeter reading as the temperature increases. [3]

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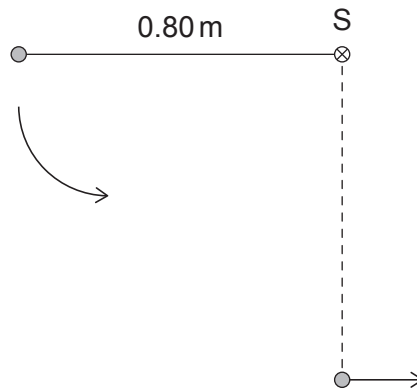
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2. A small ball of mass 0.20 kg is attached to a string of length 0.80 m that is initially horizontal. The other end of the string is fixed at S. The ball is released from rest. Air resistance is negligible.

diagram not to scale



- (a) At the instant the string is vertical,

- (i) show that the speed of the ball is about 4 m s^{-1} . [1]

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- (ii) calculate the tension in the string. [2]

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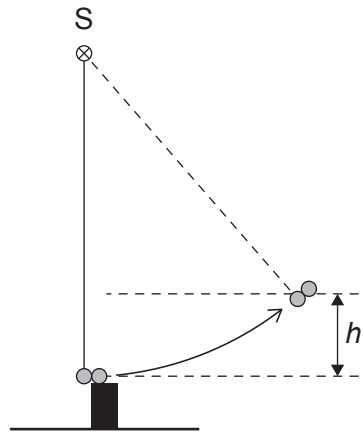
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(Question 2 continued)

- (b) Just as the string becomes vertical, the ball in (a) collides with and sticks to an identical ball. The centre of mass of the two balls is raised to a maximum height h .

diagram not to scale



Determine h .

[2]

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3. A mass of 0.25 kg of ice at -32°C is placed in water at 0°C . When thermal equilibrium is reached the temperature is 0°C . The only transfers of thermal energy are between the ice and the water.

The following data are available:

Specific heat capacity of ice = $2100\text{ J kg}^{-1}\text{ K}^{-1}$
Specific latent heat of fusion of ice = 334 kJ kg^{-1}

- (a) Show that when thermal equilibrium is reached about 50 g of water have turned into ice. [2]

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(This question continues on the following page)



(Question 3 continued)

- (b) (i) A student states that the internal energy of the 50 g of water in (a) does not change when this mass turns into ice because the temperature is constant at 0 °C. Discuss this statement.

[3]

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- (ii) Calculate the decrease in the entropy of the water.

[1]

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- (iii) Outline how the result in (b)(ii) is consistent with the second law of thermodynamics.

[2]

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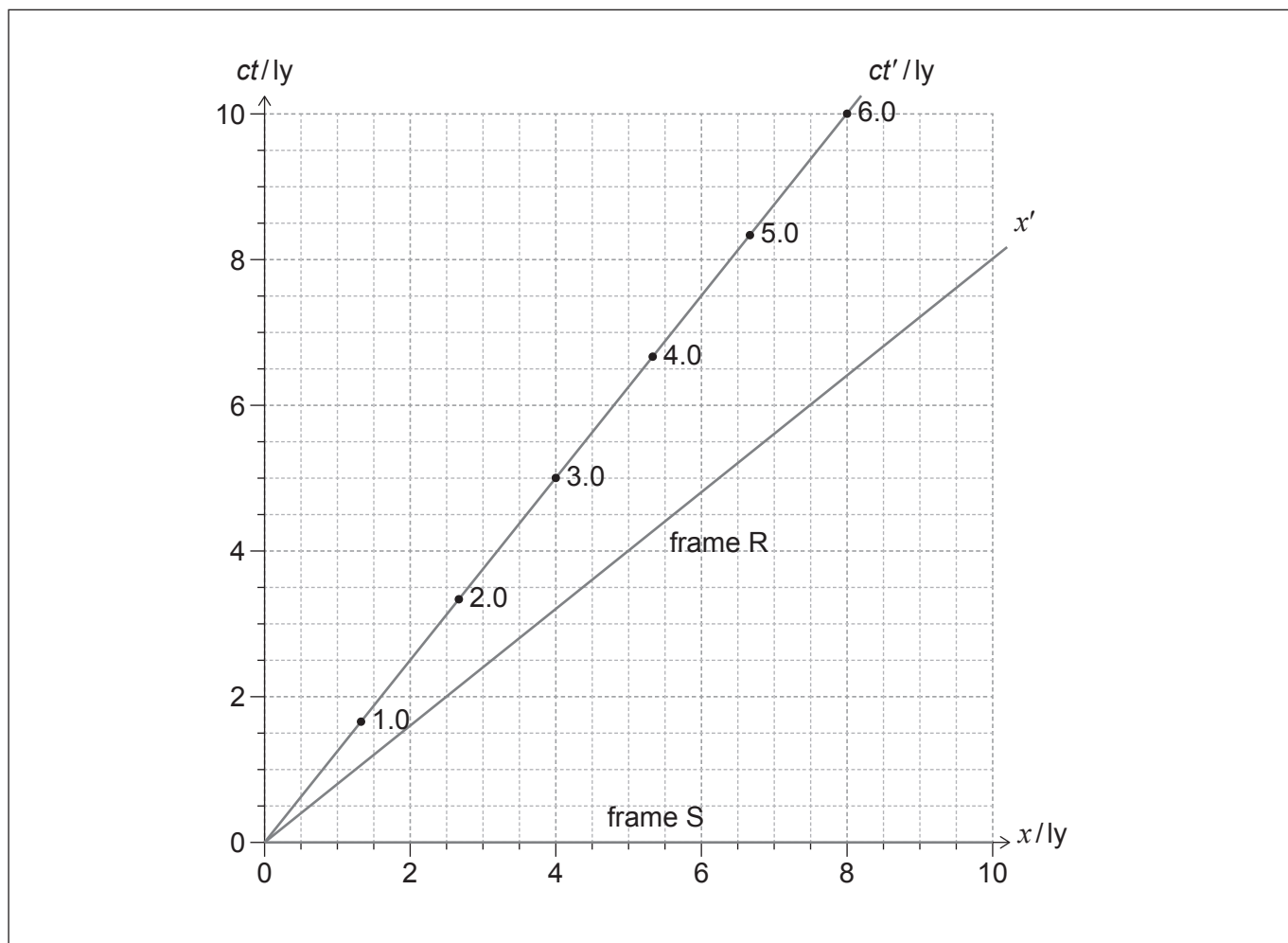
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4. A rocket R moves past a space station S. The diagram shows the space–time axes of the reference frames of R and of S.



- (a) Determine the speed of R relative to S.

[1]

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(This question continues on the following page)



(Question 4 continued)

- (b) Event E_1 is the emission of a photon from the rocket when the rocket is 4.0ly from S according to S. Event E_2 is the arrival of the photon at S.

(i) Draw the world line of the photon from E_1 to E_2 . [1]

(ii) Calculate the space–time interval between E_1 and E_2 . [1]

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(c) Calculate the time of event E_2 measured in R. [2]

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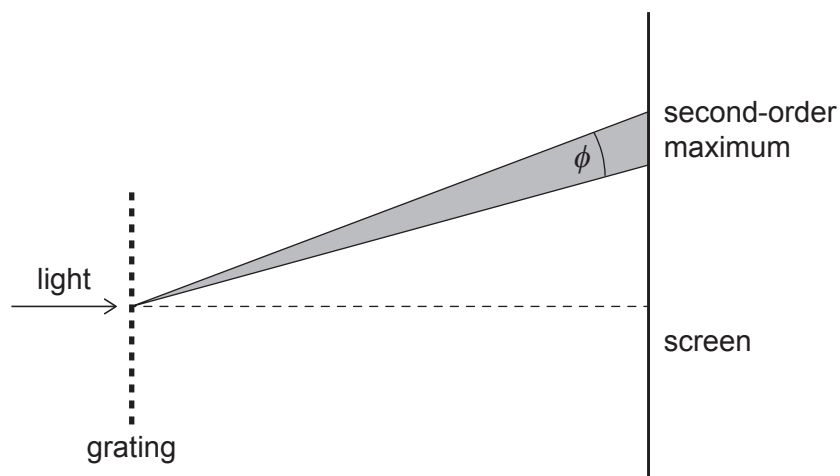
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Answers written on this page
will not be marked.



5. A diffraction grating has 400 lines per mm. Light, consisting of all wavelengths from $4.00 \times 10^{-7} \text{ m}$ to $7.00 \times 10^{-7} \text{ m}$, is incident on the grating. The **second-order** maximum is shown.

diagram not to scale



- (a) Calculate the angular width ϕ of the second-order maximum.

[2]

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- (b) Determine the largest order for which all wavelengths of the incident light are present.

[2]

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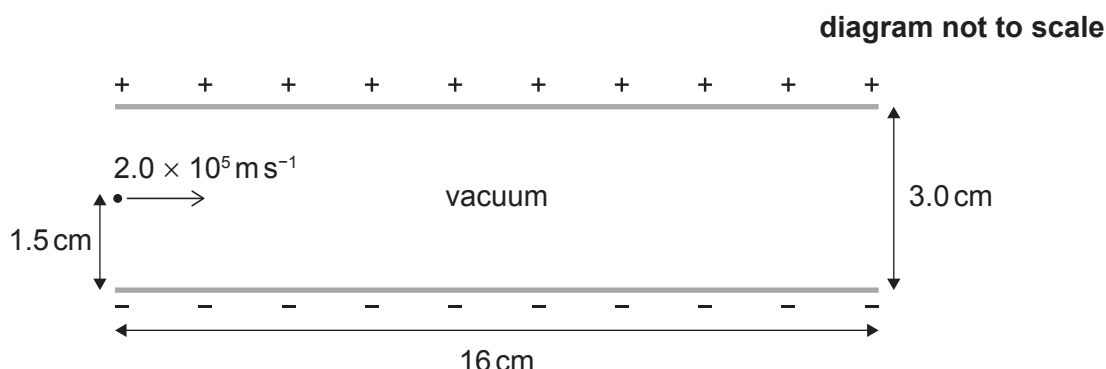
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6. Two horizontal parallel plates of length 16 cm are separated by 3.0 cm in a vacuum. The potential difference between the plates is 14 V. A proton enters the region midway between the plates with an initial horizontal velocity of $2.0 \times 10^5 \text{ m s}^{-1}$ as shown. Gravitational forces and edge effects are negligible.



- (a) (i) Calculate the magnitude of the electric field strength between the plates, including its unit.

[2]

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- (ii) Show that the acceleration of the proton is about $4.5 \times 10^{10} \text{ m s}^{-2}$.

[2]

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(This question continues on the following page)



(Question 6 continued)

- (iii) Determine whether the proton will hit the lower plate.

[3]

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- (b) An alpha particle enters the field at the same point and with the same initial velocity as the proton.

- (i) State and explain whether the alpha particle will hit the lower plate.

[2]

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- (ii) A magnetic field is established between the plates so that the alpha particle is not deflected. Determine the magnitude **and** direction of the magnetic field.

[2]

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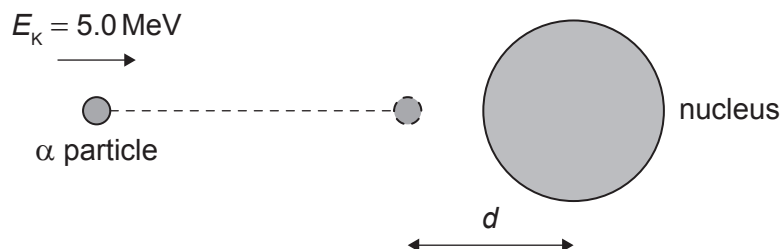
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7. An alpha particle has kinetic energy $E_k = 5.0 \text{ MeV}$ when far from a nucleus. The alpha particle is directed towards the centre of the nucleus. The distance of closest approach is $d = 1.61 \times 10^{-14} \text{ m}$.

diagram not to scale



- (a) Calculate the proton number of the nucleus.

[2]

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- (b) (i) The nucleon number of the nucleus is 58. Show that $d \approx 3.5R$ where R is the radius of the nucleus.

[2]

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- (ii) State and explain whether d will change when the nucleus is replaced by one of its isotopes.

[2]

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(This question continues on the following page)



(Question 7 continued)

- (c) (i) Suggest why deviations from Rutherford scattering are expected as the kinetic energy of the alpha particle increases. [2]

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- (ii) Deviations will appear when $d \approx R$. Estimate the initial kinetic energy of the alpha particle for which this happens. [2]

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8. An elastic rope behaves as a spring that obeys Hooke's law with a spring constant k .

(a) State what is meant by Hooke's law.

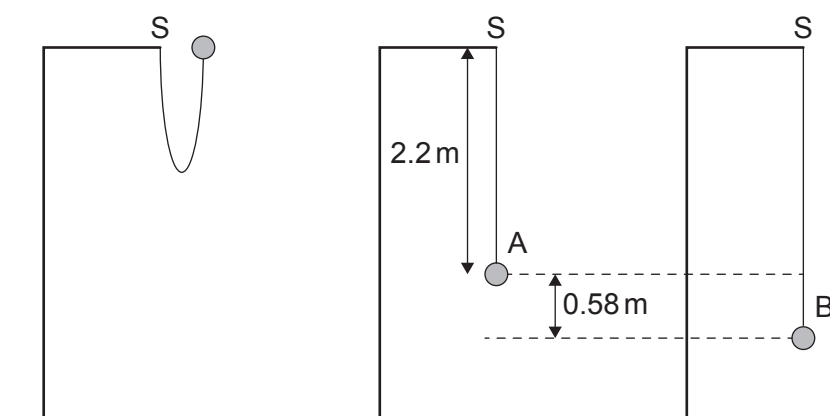
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- (b) A ball of mass 4.0 kg is attached to an elastic rope of an unstretched length of 2.2 m .

The other end of the rope is fixed at S. The ball is released from rest at S and falls vertically. The diagram shows the position of the ball at three different times. Air resistance is negligible.

diagram not to scale



- (i) The ball falls freely to A before the rope begins to stretch. Calculate the speed of the ball at A.

[2]

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(This question continues on the following page)



(Question 8 continued)

- (ii) At B the rope has reached its maximum extension of 0.58 m. Show that k for the rope is about 650 N m^{-1} .

[2]

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- (iii) State and explain whether the ball is in equilibrium at position B.

[2]

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- (iv) The time to fall from A to B is 0.13 s. Estimate the average force exerted on the ball by the rope.

[3]

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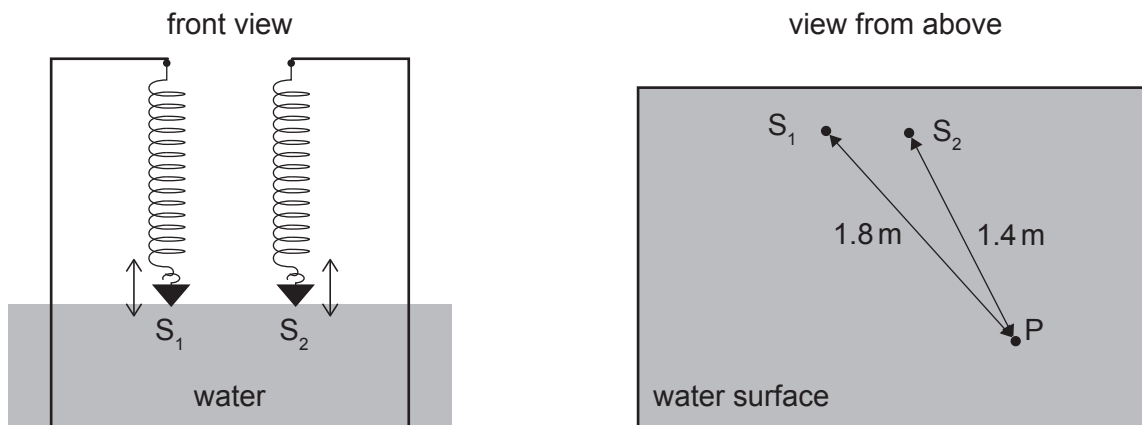
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(Question 8 continued)

- (c) Two identical wedges are attached to two identical vertical springs. The wedges touch a water surface at S_1 and S_2 . As the wedges oscillate, they create travelling waves on the water surface. The wedges oscillate in phase with the same amplitude. P is a point on the surface of the water.

diagrams not to scale



- (i) The mass of each wedge is 0.200 kg and the spring constant is 504 N m^{-1} . Damping is negligible. Show that the frequency of oscillations is about 8 Hz .

[2]

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- (ii) The speed of the water waves is 1.6 m s^{-1} . Show that the wavelength of the water waves is 0.20 m .

[1]

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(This question continues on the following page)



(Question 8 continued)

- (iii) P is 1.8 m from S_1 and 1.4 m from S_2 . Explain why the amplitude of oscillations at P will be maximum. [2]

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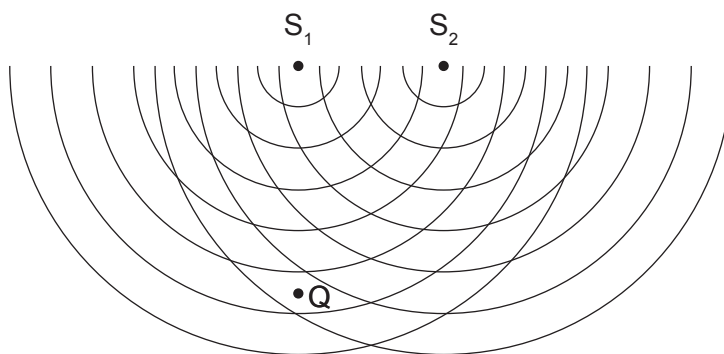
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- (iv) The diagram shows, at an instant of time, another point Q on the water surface and wavefronts that were emitted by S_1 and S_2 .

diagram not to scale



State and explain what will be observed at Q.

[2]

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- (d) The frequency of oscillation of the two wedges is increased. Determine the next frequency above 8 Hz for which the amplitude at P is again a maximum. [3]

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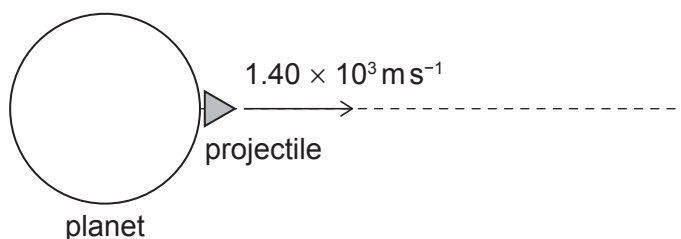
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9. (a) The escape speed from the surface of a planet with no atmosphere is $1.20 \times 10^3 \text{ m s}^{-1}$. A projectile is launched from the surface of this planet with speed $1.40 \times 10^3 \text{ m s}^{-1}$.

diagram not to scale



- (i) State what is meant by escape speed. [1]

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- (ii) Determine the speed of the projectile at a very large distance from the planet. [3]

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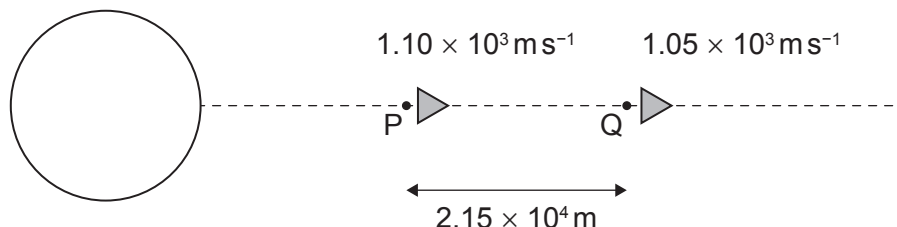
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(Question 9 continued)

- (iii) The speed of the projectile decreases from $1.10 \times 10^3 \text{ ms}^{-1}$ at P to $1.05 \times 10^3 \text{ ms}^{-1}$ at Q.

diagram not to scale



The distance PQ is $2.15 \times 10^4 \text{ m}$.

Determine the average gravitational field strength between P and Q.

[2]

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- (b) (i) A celestial body has a mass of 40 solar masses. The solar mass is $2.0 \times 10^{30} \text{ kg}$. The radius of this body is $1.15 \times 10^5 \text{ m}$. Show that the escape speed at the surface of this body is about $3 \times 10^8 \text{ ms}^{-1}$.

[2]

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- (ii) Outline the significance of the result in (b)(i).

[2]

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(This question continues on the following page)



(Question 9 continued)

- (c) (i) State the main element produced in fusion reactions in main sequence stars. [1]

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- (ii) Describe how main sequence stars maintain equilibrium. [2]

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(Question 9 continued)

- (d) The mass of star Lambda Cephei (λ Cephei) is 50 solar masses. One nuclear fusion reaction taking place in λ Cephei is ${}^{16}_8\text{O} + {}^{16}_8\text{O} \rightarrow {}^{28}_{14}\text{Si} + {}^4_2\text{He}$.

- (i) The following data are available for atomic masses:

$${}^{16}_8\text{O} = 15.9949\text{u}; \quad {}^{28}_{14}\text{Si} = 27.9769\text{u}; \quad {}^4_2\text{He} = 4.0026\text{u}.$$

Calculate, in MeV, the energy released in this reaction.

[2]

- (ii) Explain why this reaction can only happen in very massive stars.

[2]

- (iii) Suggest why nuclear fusion reactions will not produce any elements heavier than iron.

[1]

- (iv) Outline the likely evolution of λ Cephei.

[2]



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