Year 13 Physics

Mock Test

Time Allowed: 1 Hour 30 Minutes

Total Marks: 72

20 December 2025

Calculator Allowed

Full Name of Student: ……

1.

The London Eye consists of a large vertical circle with 32 equally-spaced passenger cabins attached to it. The wheel rotates so that each cabin has a constant speed of 0.26 m s^{-1} and moves around a circle of radius 61 m.

(a) Calculate the time taken for each cabin to make one complete revolution.

.....

[2]

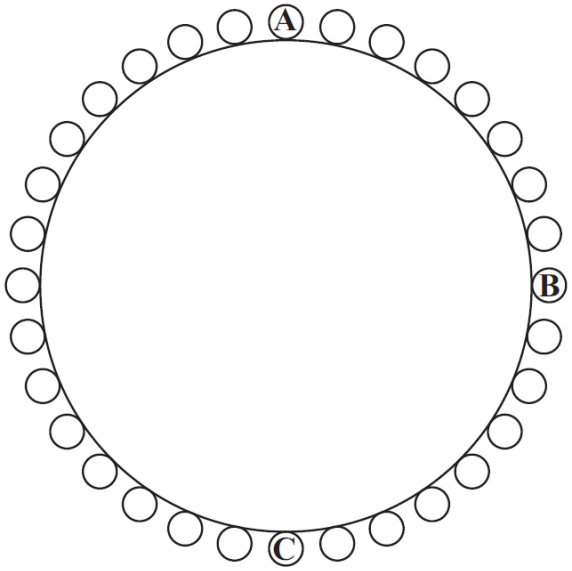
(b) Calculate the centripetal force acting on each cabin.

mass of cabin = 9.7×10^3 kg

.....

[2]

(c) (i) The diagram shows just the circle and the cabins.
Draw arrows to show the direction of the centripetal force acting on a person in a cabin when the person is at each of positions **A**, **B** and **C**.



[1]

*(ii) As the person in a cabin moves around the circle, the normal contact force between the person and the cabin varies.

State the position at which this force will be a maximum and the position at which it will be a minimum. Explain your answers.

[4]

[Total for Question 1 = 9 marks]

2.

(a) Explain what is meant by the *internal energy* of a gas.

.....

.....

.....

.....[2]

(b) A bicycle tyre has a volume of $2.1 \times 10^{-3}\,m^3$. On a day when the temperature is 15 °C the pressure of the air in the tyre is 280 kPa. Assume that air behaves as an ideal gas.

(i) Calculate the number of moles n of air in the tyre.

n = ... mol [3]

(ii) The bicycle is ridden vigorously so that the tyres warm up. The pressure in the tyre rises to 290 kPa. Calculate the new temperature of the air in the tyre. Assume that no air has leaked from the tyre and that the volume is constant.

temperature = ... °C [3]

(iii) Calculate, for the air in the tyre, the ratio

$$\frac{\text{internal energy at the higher temperature}}{\text{internal energy at } 15^{\circ}\text{C}}.$$

ratio = ……..

Justify your reasoning.

.....

.....[2]

[Total for Question 2 = 10 marks]

3.

A mass oscillates on the end of a spring in simple harmonic motion. The graph of the acceleration a of the mass against its displacement x from its equilibrium position is shown in Fig. 1.1.

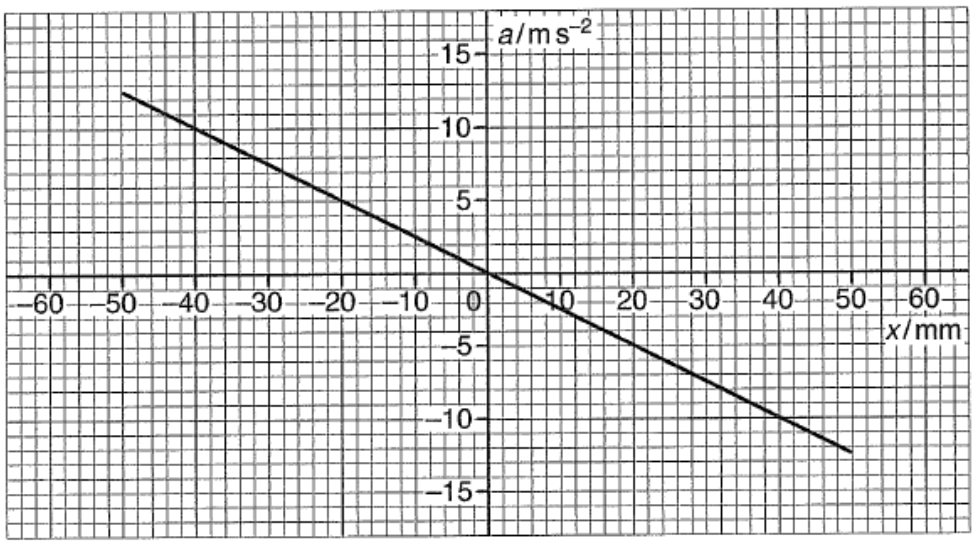


Fig. 1.1

(a) (i) Define *simple harmonic motion.*

.....

.....

.....[2]

(ii) Explain how the graph shows that the object is oscillating in simple harmonic motion.

.....

.....

.....[2]

(b) Use data from the graph

(i) to find the amplitude of the motion

amplitude = ... m [1]

(ii) to show that the period of oscillation is 0.4 s.

[3]

(c) **(i)** The mass is released at time $t = 0$ at displacement $x = 0.050$ m. Draw a graph on the axes of Fig. 1.2 of the displacement of the mass until $t = 1.0$ s. Add scales to both axes. [3]

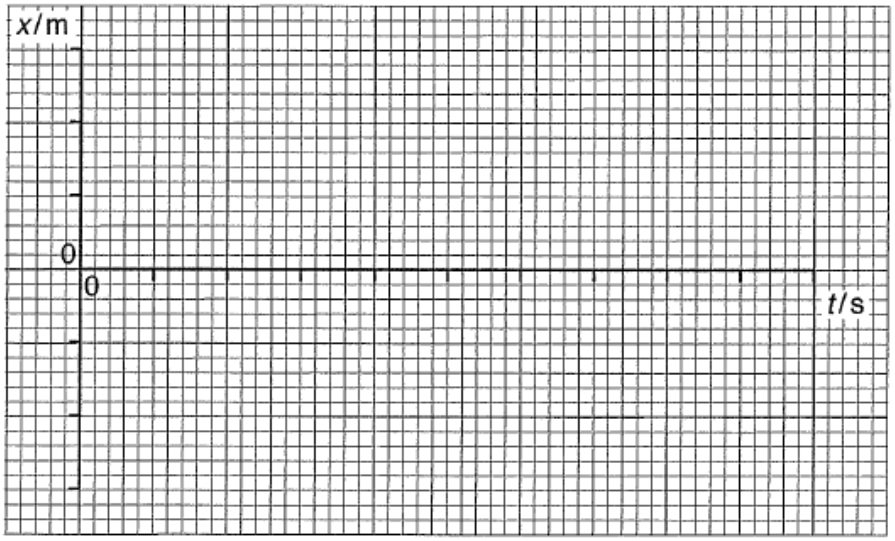


Fig. 1.2

(ii) State a displacement and time at which the system has maximum kinetic energy.

displacement ..... m

time ..... s [2]

[Total for Question 3 = 13 marks]

4.

(a) Define the *farad*.

..... **[1]**

(b) Fig. 2.1 shows a capacitor **C** of capacitance 5.4 nF connected to a battery. The switch S_1 is closed and the capacitor is charged to a p.d. of 12 V.

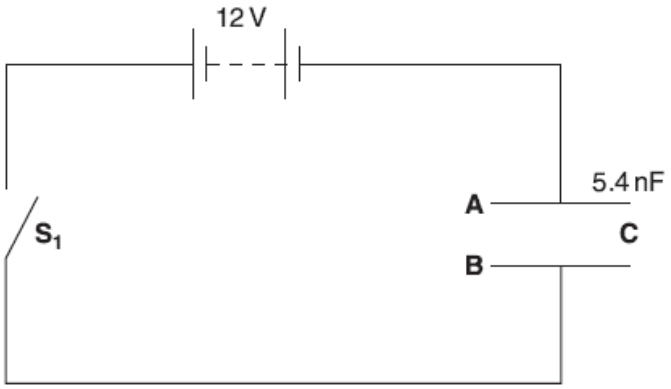


Fig. 2.1

The plates of the capacitor are labelled **A** and **B**.

(i) Explain how the plates of the capacitor become charged in terms of the movement of charged particles in the circuit.

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.....

.....

..... **[2]**

(ii) Calculate

1 the charge stored by the capacitor

charge = ... C **[1]**

2 the energy transferred to the capacitor.

energy = ... J **[1]**

(c) Fig. 2.2 shows the capacitor **C** connected to a resistor **R**.

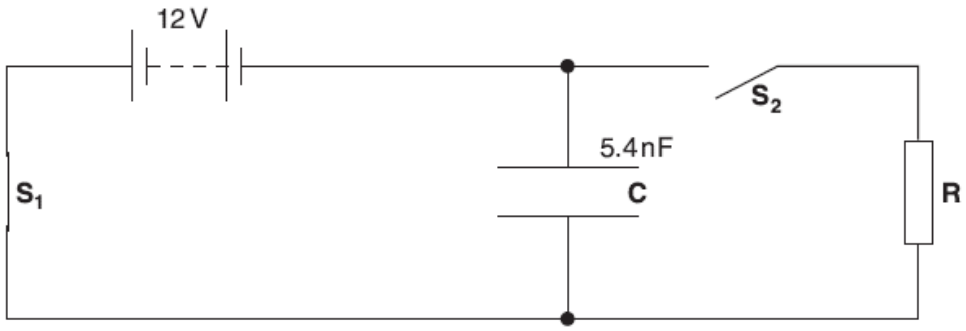

Fig. 2.2

The switch S_1 is now opened and switch S_2 is closed. The current in the resistor **R** is monitored. The initial current through **R** is 3.24 μA.

(i) Show that the resistance of the resistor **R** is 3.7 MΩ.

[1]

(ii) Calculate the current through **R** after a time $t = 0.080$ s.

current = ... μA **[2]**

(d) Explain the effect on the initial rate of discharge of the capacitor when a second resistor of resistance 3.7 MΩ is connected in parallel with the resistor **R**.

.....

.....

.....

..... **[2]**

[Total for Question 4 = 10 marks]

5.

For this question, take the mass of the Earth as 6.00×10^{24} kg.

(a) A satellite of mass 2.5×10^3 kg is to be moved from the surface of the Earth to an orbit of radius 1.6×10^7 m around the Earth.

(i) Calculate the gravitational force acting on the satellite when in orbit.

.....

.....

.....

.....

(ii) Given that the gravitational potential at the surface of the Earth (due to the Earth) is $-63\ \text{MJ kg}^{-1}$, calculate the increase in the gravitational potential energy of the satellite when it is placed in the orbit.

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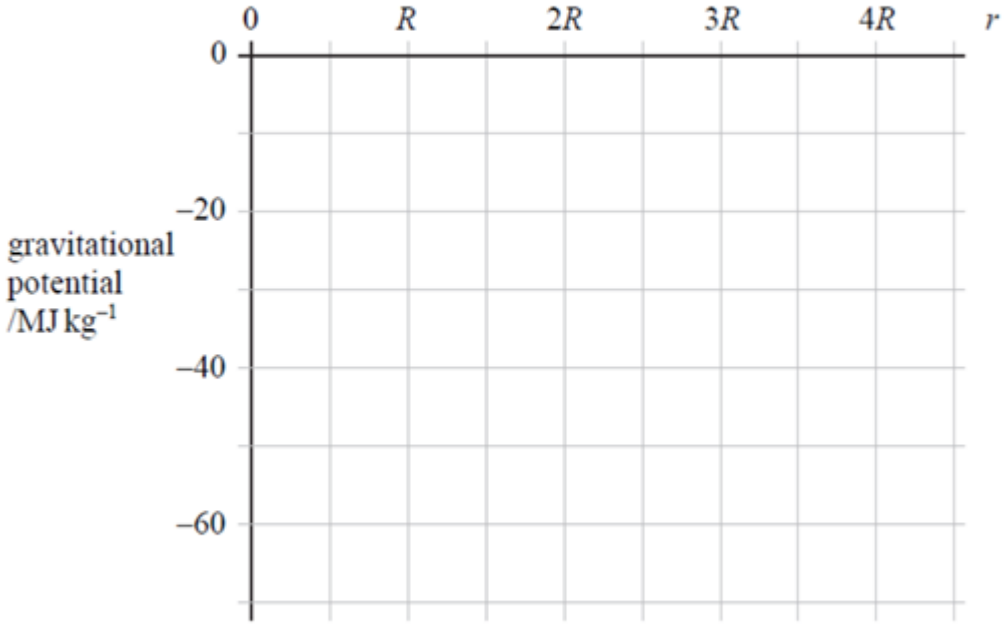
.....

.....

(5 marks)

(b) Draw a graph on the axes below to show how the gravitational potential due to the Earth varies with distance, r, measured from the centre of the Earth, for points outside the Earth. On the horizontal axis, R is the radius of the Earth.



(3 marks)

[Total for Question 5 = 8 marks]

6.

This question is about electric fields.

(a) Fig. 2.1 shows the electric field pattern drawn by a student for two oppositely charged plates.

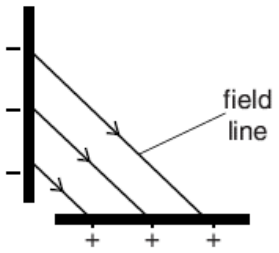


Fig. 2.1

State **two** errors made by the student in this drawing of the field pattern.

.....

.....

..... **[2]**

(b) At a distance r from the centre of a radioactive nucleus the electric field strength is E.

Fig. 2.2 shows the graph of the electric field strength E against $\frac{1}{r^2}$.

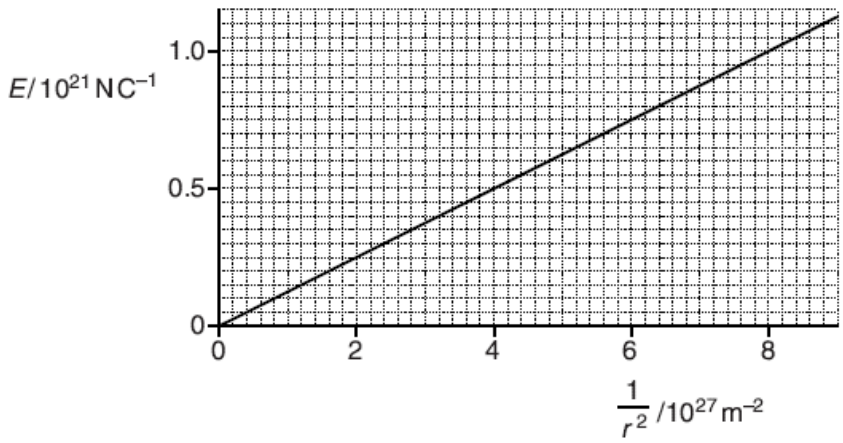


Fig. 2.2

(i) The electric field strength is given by the equation $E = \frac{Q}{4\pi\varepsilon_0 r^2}$.

Determine the gradient of the line and hence calculate the charge on the nucleus.

charge = ... C **[2]**

(ii) The radioactive nucleus emits an alpha particle.
State the change, if any, to the graph shown in Fig. 2.2 for the resultant (daughter) nucleus. Explain your answer.

.....

.....

.....

..... **[2]**

(c) A negatively charged droplet of oil is held **stationary** between two horizontal plates. The potential difference between the plates is 1.50 kV. Fig. 2.3 shows the two forces acting on this charged droplet.

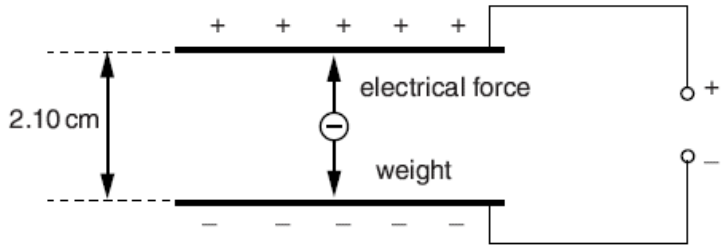


Fig. 2.3

The droplet is spherical and has a radius of 1.27×10^{-6} m. The density of oil is 950 kg m^{-3}. The separation between the plates is 2.10 cm.

(i) Show that the magnitude of the charge on the droplet is about 1.1×10^{-18} C.

[3]

(ii) Calculate the number of electrons causing the charge on the droplet.

number of electrons = ... **[1]**

[Total for Question 6 = 10 marks]

7.

(a) Fig. 2.1 shows a graph of the variation of the gravitational field strength g of the Earth with distance r from its centre.

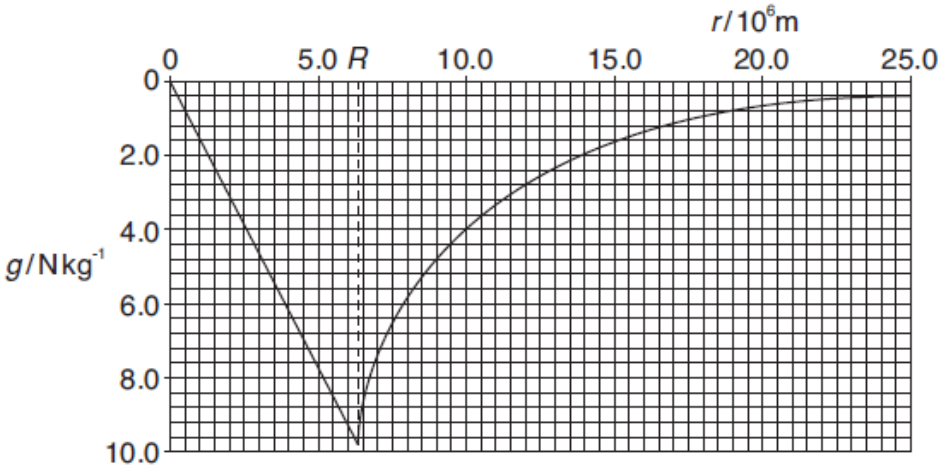


Fig. 2.1

(i) Define *gravitational field strength at a point*.

.....

.....[1]

(ii) Write down an algebraic expression for the gravitational field strength g at the surface of the Earth in terms of its mass M, its radius R and the universal gravitational constant G.

[1]

(iii) Use data from Fig. 2.1 and the value of G to show that the mass of the Earth is 6.0×10^{24} kg.

[2]

(iv) State which feature of the graph in Fig. 2.1 indicates that the gravitational field strength at a point below the surface of the Earth, assumed to be of uniform density, is proportional to the distance from the centre of the Earth.

.....

.....[1]

(v) Calculate the **two** distances from the centre of the Earth at which $g = 0.098\ \text{N kg}^{-1}$. Explain how you arrived at your answers.

distance 1 .....

.....

.....[2]

distance 2 .....

.....

.....[2]

(b) A spacecraft on a journey from the Earth to the Moon feels no resultant gravitational pull from the Earth and the Moon when it has travelled to a point 0.9 of the distance between their centres. Calculate the mass of the Moon, using the value for the mass of the Earth in **a(iii)**.

mass = ... kg [3]

[Total for Question 7 = 12 marks]

- End of Test -
