School	*Candidate's Name (PLEASE PRINT)*

WINCHESTER
COLLEGE

WINCHESTER ELECTION

Physics Examination

2024

THEORY SECTION

Recommended time: 20 minutes

Write all your answers in the spaces on this question paper

An electronic calculator is required

MAXIMUM MARK = 25

1 The Moon orbits the Earth once every 27.3 days. The distance from the centre of the Earth to the centre of the Moon is approximately 60 times larger than the Earth's radius, which is $R_{Earth} = 6.37 \times 10^6$ m

The Moon has a radius of $R_{Moon} = 1.74 \times 10^6$ m and a mass of $M_{Moon} = 7.35 \times 10^{22}$ kg.

(a) Show that the time it takes the Moon to orbit the Earth can be written $T = 2.36 \times 10^6$ s.

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..... [1]

(b) The Moon's orbit is approximately circular. Show that the Moon travels 2.40×10^9 m in its orbit around the Earth.

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..... [2]

(c) Calculate the orbital speed of the Moon.

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..... [2]

(d) Calculate the density of the Moon.
The volume of a sphere of radius R is $V = \frac{4}{3}\pi R^3$

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..... [3]

(e) It is often suggested that the Moon looks like it is made of cheese. The average density of cheese is about 700 kg/m^3.

A 285g block of cheese costs £3.20.

Calculate how much it would cost to form a solid sphere of cheese which is the same size as the Moon.

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..... [3]

(f) The pictures below show a series of images representing how the Sun will appear during the total solar eclipse in Dublin, Ohio, USA in April 2024.

(i) Draw a labelled diagram to show the arrangement of the Sun, Earth and Moon during a total solar eclipse.

[3]

(ii) Explain why it is not sensible to draw this diagram to the correct scale.

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[2]

(iii) A pupil plans to build an electrical circuit to find the exact moment when the amount of light reaching the Earth during the solar eclipse is a minimum. They have access to their usual electrical equipment, including:

a cell
a fixed resistor
an LED
a switch
an LDR
an ammeter
some wires

Draw a circuit diagram of a circuit, using some of these components, that is able to measure the light level.

[2]

(iv) Describe how the pupil could use their circuit to identify when the light level is lowest.

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..... [2]

2 Kepler's Third Law of planetary orbital motion states that the square of the orbital time period T of a planet's orbit around the sun is directly proportional to the cube of the planet's orbital radius r around the sun:

$$T^2 \propto r^3$$

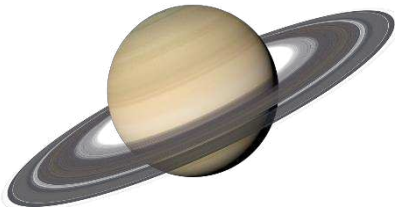
When the orbital time period T is measured in Earth years, and the orbital radius r is measured in Astronomical Units (AU), the relationship can be re-written as

$$T^2 = \frac{r^3}{M}$$

where M is the mass of the star at the centre of the solar system relative to the mass of the sun (i.e. the mass of the sun would be 1.0, the mass of a star 3 times heavier than the sun would be M = 3.0).

1 AU is the radius of the Earth's orbit.

Saturn orbits the Sun with a radius of 9.5 AU.



(a) Use Kepler's Third law to calculate the period of the orbit of Saturn (in years).

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..... [2]

(b) Gliese 667 Cc is an exoplanet orbiting the red dwarf star Gliese 667 C. It is about 23.6 light-years away from Earth in the constellation of Scorpius.

Gliese 667 Cc completes one orbit in 28 days, at an orbital radius of 0.125 AU.

Use this information to calculate the mass M of star Gliese 667 C relative to our sun.

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..... [3]

Total marks: 25

End of this paper

References:

Eclipse – City of Dublin, Ohio, USA (dublinohiousa.gov)
Spacepedia | Solar System Scope