THE NEW ZEALAND OLYMPIAD OF ASTRONOMY AND ASTROPHYSICS

CHALLENGE EXAM

OCTOBER 15, 2025

Time allowed: **ONE HOUR**

Permitted materials: **CLOSED BOOK**
Calculators allowed, with memories cleared.

Instructions:

You will be marked on ALL questions in Section A and B but only **one** question in Section C. If you attempt more than one Section C question, your **best** mark will be taken for the total.

The exam will be marked out of a total of **30** marks.

You can use formulas given without rederiving them, unless explicitly requested.

You may detach the formula sheet from the back, it is not required to be handed in with the paper.

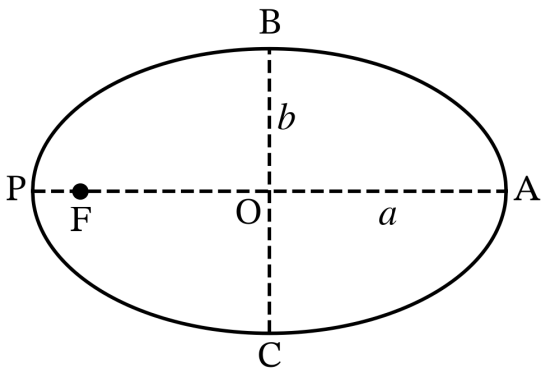
APPENDIX

Constants

Constant	Symbol	Value
Speed of light	c	$3.00 \times 10^{8}\ \mathrm{m\ s^{-1}}$
Earth's rotation period	1 day	24 hours
Earth's orbital period	1 year	365.25 days
parsec	pc	$3.09 \times 10^{16}\ \mathrm{m}$
Astronomical Unit	AU	$1.50 \times 10^{11}\ \mathrm{m}$
Semi-major axis of the Earth's orbit		1 AU
Radius of the Sun	$R_\odot$	$6.98 \times 10^{8}\ \mathrm{m}$
Mass of the Sun	$M_\odot$	$1.99 \times 10^{30}\ \mathrm{kg}$
Mass of the Earth	M_E	$5.97 \times 10^{24}\ \mathrm{kg}$
Luminosity of the Sun	$L_\odot$	$3.85 \times 10^{36}\ \mathrm{W}$
Gravitational constant	G	$6.67 \times 10^{-11}\ \mathrm{m^3\ kg^{-1}\ s^{-2}}$

Elements of an ellipse

Symbol/ equation	Name
$a = \mathbf{OA}\ (= \mathbf{OP})$	semi-major axis
$b = \mathbf{OB}\ (= \mathbf{OC})$	semi-minor axis
$e = \sqrt{1 - \frac{b^2}{a^2}}$	eccentricity
F	focus
P	periapsis (point nearest to **F**)
A	apoapsis (point furthest from **F**)



Kepler's Third Law

For an elliptical orbit, the square of the period, T, of an object about the focus is proportional to the cube of the semi-major axis, a (as defined above), such that

$$T^2 = \frac{4\pi^2}{GM}a^3$$

where M is the total mass of the system (typically dominated by the central object) and G is the universal gravitational constant.

Magnitudes

The apparent magnitudes of two objects, m_1 and m_0, are related to their apparent brightnesses, b_1 and b_0, via the formula:

$$\frac{b_1}{b_0} = 10^{-0.4(m_1 - m_0)}$$