

Important Constants

Constant	Symbol	Value
Speed of light	c	$3.00 \times 10^8 \text{ m s}^{-1}$
Earth's rotation period	1 day	24 hours
Earth's orbital period	1 year	365.25 days
parsec	pc	$3.09 \times 10^{16} \text{ m}$
Astronomical Unit	au	$1.50 \times 10^{11} \text{ m}$
Radius of the Sun	R_{\odot}	$6.96 \times 10^8 \text{ m}$
Radius of the Earth	R_{\oplus}	$6.37 \times 10^6 \text{ m}$
Mass of the Sun	M_{\odot}	$1.99 \times 10^{30} \text{ kg}$
Mass of the Earth	M_{\oplus}	$5.97 \times 10^{24} \text{ kg}$
Luminosity of the Sun	L_{\odot}	$3.85 \times 10^{26} \text{ W}$
Stephan-Boltzmann constant	σ	$5.67 \times 10^{-8} \text{ J m}^{-2} \text{ K}^{-4}$
Gravitational constant	G	$6.67 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$
Boltzmann constant	k_B	$1.38 \times 10^{-23} \text{ J K}^{-1}$
Permittivity of free space	ϵ_0	$8.85 \times 10^{-12} \text{ F m}^{-1}$
Permeability of free space	μ_0	$4\pi \times 10^{-7} \text{ H m}^{-1}$
Planck's constant	h	$6.63 \times 10^{-34} \text{ J s}$
Elementary charge	e	$1.60 \times 10^{-19} \text{ C}$
Proton rest mass	m_p	$1.67 \times 10^{-27} \text{ kg}$
Electron rest mass	m_e	$9.11 \times 10^{-31} \text{ kg}$
Wien's displacement law	$\lambda_{\text{max}}T$	$2.90 \times 10^{-3} \text{ m K}$
Avagadro's constant	N_A	$6.02 \times 10^{23} \text{ mol}^{-1}$

Basic calculus formulae:

Chain rule $\frac{d}{dx} f(g(x)) = f'(g(x))g'(x)$

Product rule $\frac{d}{dx}(uv) = \frac{du}{dx}v + u\frac{dv}{dx}$

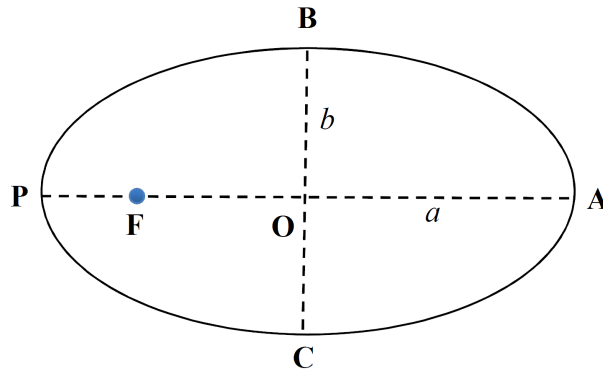
Quotient rule $\frac{d}{dx}\left(\frac{u}{v}\right) = \frac{\frac{du}{dx}v - u\frac{dv}{dx}}{v^2}$

Integration by parts $\int u\frac{dv}{dx} dx = uv - \int v\frac{du}{dx} dx$

Standard integral $\int \frac{1}{x} dx = \ln|x| + C$

Important Formulae

You might find the diagram of an elliptical orbit below useful in solving some of the questions:



Elements of an elliptic orbit:

- $a = \text{OA} (= \text{OP})$ semi-major axis
- $b = \text{OB} (= \text{OC})$ semi-minor axis
- $e = \sqrt{1 - \frac{b^2}{a^2}}$ eccentricity
- F** focus
- PF** = $a(1 - e)$ periapsis distance (shortest distance from **F**)
- AF** = $a(1 + e)$ apoapsis distance (longest distance 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.

Vis-Viva Equation: For an elliptical orbit, the speed v of an object at a distance r from the focus is related to the semi-major axis, a , total mass of the system, M , and universal gravitational constant, G , (as defined above), such that

$$v^2 = GM \left(\frac{2}{r} - \frac{1}{a} \right).$$

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

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

The absolute magnitude of an object, \mathcal{M} , is the same as its apparent magnitude when viewed from 10 pc, hence the relationship between apparent and absolute magnitude and distance is

$$m - \mathcal{M} = 5 \log \left(\frac{d}{10} \right),$$

where d is measured in parsecs.



British Astronomy and Astrophysics Olympiad 2022-23
Astronomy & Astrophysics Competition (BAAO) - March 18, 2023
Student Cover Sheet

(Please write all your information in ENGLISH. 答题册上内容全部用英文作答。)

Account Number			
School			
Student first name			
Student last name			
Nationality of student			
DOB <u>and</u> Year of Student <u>and</u> M/F			
Have you taken or are you taking part in the selection process for an International Olympiad Competition?	Yes / No (if Yes, which competition and Year)		

After you have completed the exam, please:

- Ensure that your student's name can be read on the script and also the details above
- Tell us which questions you attempted by ticking the second column of the table below
- Check that you have numbered the pages of your script
- Ensure this cover sheet is firmly attached to your exam script

Question	Tick if attempted
Q1	
Q2	
Q3	

Answer Sheet

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Answer Sheet

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