A-Level Edexcel

PHYSICS

UNIT 5(IAL)

2020 — 2025

EXAMINENT
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1 - (WPH11/5(IAL)_Summer_2024_Q12) - *Mechanics, Astrophysics And Cosmology*

The planet Uranus has nearly thirty moons. Titania is the largest of these moons.
The radius of Titania is 7.88×10^{5} m. The mass of Titania is 3.40×10^{21} kg.

Scientists plan to use a vehicle with a mass of 210 kg to explore Titania.

Calculate the weight of this vehicle on the surface of Titania.

Weight = ...

2 - (WPH11/5(IAL)_Summer_2024_Q13) - *Thermodynamics, Mechanics*

The photograph shows an airship. This consists of a large balloon filled with helium gas with a basket suspended beneath.

(Source: © Tom Bushey/Alamy Stock Photo)

(a) Explain how the airship is able to float in the air.

(2)

(b) The pressure of helium inside the balloon is 1.08×10^5 Pa at a temperature of 25 °C.

Calculate the mass of helium gas in the balloon.

volume of balloon = $7020\,\text{m}^3$
mass of a helium atom = 6.64×10^{-27} kg

(4)

Mass of helium gas = ...

1 - (WPH11/5(IAL)_Winter_2025_Q2) - *Materials, Oscillations*

Ductile materials can be used in buildings to reduce the amplitude of forced oscillations during an earthquake.

Which of the following is the reason that ductile materials are used?

☒ **A** These materials are stiff.

☒ **B** These materials are strong.

☒ **C** These materials deform elastically.

☒ **D** These materials deform plastically.

1 - (WPH11/5(IAL)_Summer_2024_Q16) - *Astrophysics And Cosmology, Waves And Particle Nature Of Light*

The star ε-Eridani is one of the closest stars to the Sun. The intensity of ε-Eridani, as measured on the Earth, is $1.05 \times 10^{-9}\,\text{W m}^{-2}$.

(a) Calculate the wavelength, λ_{max}, corresponding to the peak intensity of emission of radiation from ε-Eridani.

distance of ε-Eridani from the Earth = $9.94 \times 10^{16}\,\text{m}$
radius of ε-Eridani = $5.12 \times 10^{8}\,\text{m}$

(5)

λ_{max} = ...

(b) ε-Eridani is moving away from the Earth with a velocity of $1.55 \times 10^{4}\,\text{m s}^{-1}$.

A scientist observed the light received from ε-Eridani using a spectrometer.

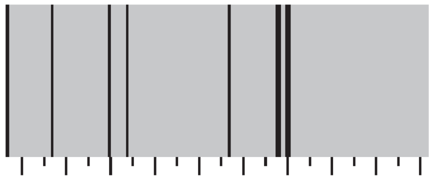
Deduce whether the scientist was able to detect a change in the wavelength of light, of wavelength 480 nm, emitted by the star.

resolution of spectrometer = 0.05 nm

(3)

2 - (WPH11/5(IAL)_Winter_2025_Q18) - *Astrophysics And Cosmology, Waves And Particle Nature Of Light*

The diagram shows dark lines in the continuous spectrum of electromagnetic radiation from the Sun.

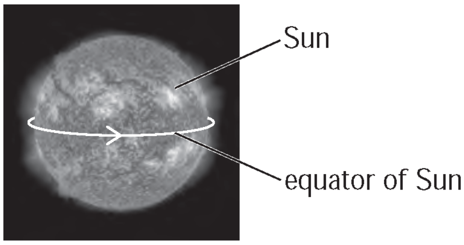


(a) Atoms in the outer regions of the Sun absorb electromagnetic radiation. This produces the dark lines in the spectrum.

Explain why electromagnetic radiation is only absorbed at some wavelengths.

(3)

(b) The Sun rotates on its axis. The diagram shows the Sun rotating at its 'equator'.



(Source: © NASA / SDO / SCIENCE PHOTO LIBRARY)

One of the dark lines in the spectrum occurs at a wavelength of 589 nm.

Radiation is received on Earth from opposite ends of the Sun's diameter. There is a difference between the wavelengths of radiation received from opposite ends due to the Sun rotating about its axis.

The difference in wavelength is 7.94×10^{-3} nm.

A website states that at its equator, the Sun rotates once every 27 days about its axis.

Assess the accuracy of this statement.

radius of Sun = 6.96×10^{8} m
1 day = 8.64×10^{4} s

(5)

1 - (WPH11/5(IAL)_Summer_2024_Q18) - *Astrophysics And Cosmology, Further Mechanics*

In the 17th century, Johannes Kepler derived his laws of planetary motion.

(a) One law related the orbital time T of a planet to its average distance r from the Sun.

Show that

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

where M is the solar mass.

(3)

(b) Luminosity measurements suggest that our galaxy has a mass equal to 8.0×10^{11} solar masses.

(i) A star in one of the outer arms of the galaxy is orbiting the centre of the galaxy. The star is 5.7×10^{20} m from the centre of the galaxy.

Show that the orbital period of the star should be about 8×10^{15} s.

solar mass = 1.99×10^{30} kg

(2)

(ii) The orbital period of the star is actually 6.0×10^{7} s.

The two values for the orbital period of the star do not agree.

Deduce what this tells us about our galaxy.

Assume that the value for the distance of the star from the centre of our galaxy is correct.

(4)

2 - (WPH11/5(IAL)_Summer_2025_Q17) - *Thermodynamics, Further Mechanics, Astrophysics And Cosmology*

The Gaia globe is a three-dimensional model of the Earth, as shown. The inflated globe is suspended from above and is able to rotate.

The globe is filled with nitrogen gas. When fully inflated the globe has a radius of 3.50 m.

(a) Calculate the mass of nitrogen gas needed to exert a pressure of 1.12×10^5 Pa inside the globe, at a temperature of 22.0 °C.

mass of a nitrogen molecule = 4.67×10^{-26} kg

(5)

(b) The globe rotates with an angular velocity of 2.76×10^{-2} rad s^{-1}.

Calculate the time taken for the globe to make one complete rotation.

(2)

(c) A solid sphere has the same diameter as the Gaia globe.

Calculate the mass of the sphere that would give a value of *g*, at its surface, of 9.8 N kg^{-1}.

(2)

3 - (WPH11/5(IAL)_Winter_2025_Q3) - *Further Mechanics, Electric And Magnetic Fields*

There is an electric field around a point charge and a gravitational field around a point mass.

Which of the following is **not** correct?

☒ **A** Both fields are radial.

☒ **B** Both fields can produce attractive forces.

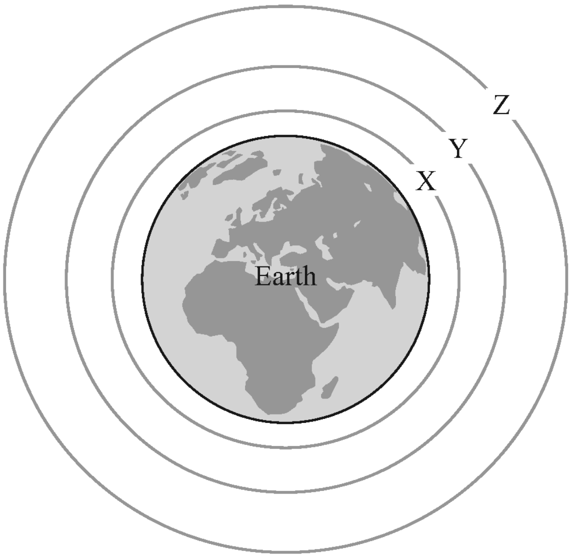
☒ **C** Both fields can produce repulsive forces.

☒ **D** Both fields produce forces that obey an inverse square law.

1 - (WPH11/5(IAL)_Summer_2024_Q11) - *Astrophysics And Cosmology, Electric And Magnetic Fields*

The diagram shows the Earth and some gravitational equipotential surfaces X, Y and Z.

The difference in gravitational potential between X and Y is the same as the difference in gravitational potential between Y and Z.



Explain why the equipotential surfaces are not equally spaced.

2 - (WPH11/5(IAL)_Winter_2025_Q3) - *Further Mechanics, Electric And Magnetic Fields*

There is an electric field around a point charge and a gravitational field around a point mass.

Which of the following is **not** correct?

☒ **A** Both fields are radial.

☒ **B** Both fields can produce attractive forces.

☒ **C** Both fields can produce repulsive forces.

☒ **D** Both fields produce forces that obey an inverse square law.

ANSWERS

1 - (WPH11/5(IAL)_Summer_2024_Q12) - *Mechanics, Astrophysics And Cosmology*

	Use of $g = \frac{GM}{r^2}$	**(1)**	
	Use of $W = mg$	**(1)**	
	$W = 77$ N	**(1)**	**3**
	Example of calculation $g = \frac{6.67 \times 10^{-11}\ \mathrm{N\ m^2\ kg^{-2}} \times 3.40 \times 10^{21}\ \mathrm{kg}}{(7.88 \times 10^5\ \mathrm{m})^2} = 0.365\ \mathrm{N\ kg^{-1}}$ $F = 210\ \mathrm{kg} \times 0.365\ \mathrm{N\ kg^{-1}} = 76.7\ \mathrm{N}$		

2 - (WPH11/5(IAL)_Summer_2024_Q13) - *Thermodynamics, Mechanics*

(a)	<u>Upthrust</u> on airship is equal to the <u>weight</u> of the airship	**(1)**	
	(so) resultant force on the airship is zero (so airship floats in the air) **Or** (vertically) balanced forces act on the airship	**(1)**	**2**
	If neither MP seen, max 1 mark for statement indicating that upwards force is equal to downwards force.		
(b)	Use of $pV = NkT$	**(1)**	
	Conversion of temperature to K	**(1)**	
	Use of $M = Nm$	**(1)**	
	$M = 1200$ kg	**(1)**	**4**
	Example of calculation $N = \frac{pV}{kT} = \frac{1.08 \times 10^5\ \mathrm{Pa} \times 7020\ \mathrm{m^3}}{1.38 \times 10^{-23}\ \mathrm{m^2\ kg\ s^{-2}\ K^{-1}} \times (273 + 25)\ \mathrm{K}} = 1.84 \times 10^{29}$ $M = 1.84 \times 10^{29} \times 6.64 \times 10^{-27}\ \mathrm{kg} = 1220\ \mathrm{kg}$		

1 - (WPH11/5(IAL)_Winter_2025_Q2) - *Materials, Oscillations*

	D is the correct answer (these materials deform plastically) A is not correct because this will not absorb energy from the oscillation B is not correct because this will not absorb energy from the oscillation C is not correct because this will absorb and then return energy to the oscillation	**1**

1 - (WPH11/5(IAL)_Summer_2024_Q16) - *Astrophysics And Cosmology, Waves And Particle Nature Of Light*

(a)	Use of $I = \frac{L}{4\pi d^2}$ Use of $L = \sigma A T^4$ Use of $A = 4\pi r^2$ Use of $\lambda_{\max} T = 2.898 \times 10^{-3}$ m K $\lambda_{\max} = 5.64 \times 10^{-7}$ m <u>Example of calculation</u> $1.05 \times 10^{-9}\ \text{W m}^{-2} = \frac{L}{4\pi \times (9.94 \times 10^{16}\ \text{m})^2}$ $L = 4\pi \times (9.94 \times 10^{16}\ \text{m})^2 \times 1.05 \times 10^{-9}\ \text{W m}^{-2} = 1.30 \times 10^{26}$ W $A = 4\pi \times (5.12 \times 10^8\ \text{m})^2 = 3.29 \times 10^{18}\ \text{m}^2$ $1.30 \times 10^{26}\ \text{W} = 5.67 \times 10^{-8} \text{W m}^{-2}\text{K}^{-4} \times 3.29 \times 10^{18}\ \text{m}^2 \times T^4$ $T = \sqrt[4]{\frac{1.30 \times 10^{26}\ \text{W}}{5.67 \times 10^{-8}\ \text{W m}^{-2}\text{K}^{-4} \times 3.29 \times 10^{18}\ \text{m}^2}} = 5140$ K $\lambda_{\max} = \frac{2.898 \times 10^{-3}\ \text{m K}}{5140\ \text{K}} = 5.64 \times 10^{-7}$m	**(1)** **(1)** **(1)** **(1)** **(1)**	**5**
(b)	Use of $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ [Allow a 2 step approach using a calculation of the red shift, *z*] $\Delta\lambda = 0.025$ nm 0.025 (nm) < 0.05 (nm), so no wavelength change could be detected **Or** comparison of calculated value with 0.05 (nm) and consistent conclusion made. <u>Example of calculation</u> $\frac{\Delta\lambda}{480\ \text{nm}} = \frac{1.55 \times 10^4\ \text{m s}^{-1}}{3.00 \times 10^8\ \text{m s}^{-1}}$ $\Delta\lambda = 480\ \text{nm} \times 5.17 \times 10^{-5} = 0.0248$ nm	**(1)** **(1)** **(1)**	**3**

2 - (WPH11/5(IAL)_Winter_2025_Q18) - *Astrophysics And Cosmology, Waves And Particle Nature Of Light*

(a)	Electron/atomic energy levels are discrete **Or** Electrons can only have certain energy states **(1)** A <u>photon</u> is absorbed with an energy equal to the difference in the energy between two energy levels **(1)** Only certain (energy level) transitions are possible (so only some wavelengths/frequencies are absorbed) **(1)**	**3**
(b)	Use of $\frac{\Delta\lambda}{\lambda} \approx \frac{v}{c}$ **(1)** Use of $v = \omega r$ **(1)** Use of $\omega = \frac{2\pi}{T}$ **(1)** Conversion between seconds and days **(1)** $T = 25$ days < 27 days, so statement not accurate **Or** $T = 25$ days ≈ 27 days, so statement accurate **(1)** **ALTERNATIVE SOLUTION:** Use of $\omega = \frac{2\pi}{T}$ to calculate angular velocity of Sun **(1)** Use of $v = \omega r$ to calculate rotational velocity of (edge of) Sun **(1)** Use of $\frac{\Delta\lambda}{\lambda} \approx \frac{v}{c}$ to calculate wavelength for approaching and receding side **(1)** Calculate difference in λ for each side of Sun **(1)** $\Delta\lambda = 7.36 \times 10^{-3}$ nm < 7.94×10^{-3} nm, so statement is inaccurate **(1)** <u>Example of calculation</u> $\Delta\lambda = \frac{7.94 \times 10^{-3}\text{ nm}}{2} = 3.97 \times 10^{-3}\text{ nm}$ $v = \left(\frac{3.97 \times 10^{-3}\text{ nm}}{589\text{ nm}}\right) \times 3.00 \times 10^{8}\text{ m s}^{-1} = 2.02 \times 10^{3}\text{ m s}^{-1}$ $\omega = \frac{2.02 \times 10^{3}\text{ m s}^{-1}}{6.96 \times 10^{8}\text{ m}} = 2.91 \times 10^{-6}\text{ rad s}^{-1}$ $T = \frac{2\pi\text{ rad}}{2.91 \times 10^{-6}\text{ rad s}^{-1}} = 2.16 \times 10^{6}\text{ s}$ $T = \frac{2.16 \times 10^{6}\text{ s}}{8.64 \times 10^{4}\text{ s day}^{-1}} = 25\text{ days}$	**5**

1 - (WPH11/5(IAL)_Summer_2024_Q18) - *Astrophysics And Cosmology, Further Mechanics*

(a)	Gravitational force equated to centripetal force Substitution of $\omega = \frac{2\pi}{T}$ **Or** Substitution of $v = \frac{2\pi r}{T}$ Algebra to obtain required expression <u>Example of derivation</u> $m\omega^2 r = \frac{GMm}{r^2}$ $m\left(\frac{2\pi}{T}\right)^2 r = \frac{GMm}{r^2}$ $T^2 = \frac{4\pi^2}{GM} r^3$	**(1)** **(1)** **(1)**	**3**
(b)(i)	Use of $T^2 = \frac{4\pi^2 r^3}{GM}$ $T = 8.3 \times 10^{15}$ (s) <u>Example of calculation</u> $T = \sqrt{\frac{4\pi^2 \times (5.7 \times 10^{20}\ \text{m})^3}{6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2} \times 8.0 \times 10^{11} \times 1.99 \times 10^{30}\ \text{kg}}}$ $\therefore T = 8.30 \times 10^{15}$ s	**(1)** **(1)**	**2**
(b)(ii)	The actual period is (much) smaller than the calculated value So the mass of the galaxy must be greater than 8.0×10^{11} solar masses [accept the given mass for the numerical value] **Or** the gravitational force on the star must be bigger (than assumed) There must be matter that does not emit em-radiation **Or** There must be matter that we cannot detect via em-radiation [Accept "there must be matter that we cannot see"] (This suggests that) there is dark matter	**(1)** **(1)** **(1)** **(1)**	**4**

2 - (WPH11/5(IAL)_Summer_2025_Q17) - *Thermodynamics, Further Mechanics, Astrophysics And Cosmology*

(a)	Substitute into $V = \frac{4}{3}\pi r^3$ Use of $pV = NkT$ Conversion of temperature to kelvin Use of number of molecules to calculate mass of gas $m = 230$ kg	**(1)** **(1)** **(1)** **(1)** **(1)**	Do not credit $pV = nRT$ unless final answer is correct If answer incorrect, *could* award marks for MP1, MP3, MP4 Example of calculation $V = \frac{4}{3}\pi \times (3.5\ \text{m})^3 = 179.6\ \text{m}^3$ $N = \frac{1.12 \times 10^5\ \text{Pa} \times 179.6\ \text{m}^3}{1.38 \times 10^{-23}\text{J K}^{-1} \times (273 + 22)\ \text{K}} = 4.94 \times 10^{27}$ $m = 4.94 \times 10^{27} \times 4.67 \times 10^{-26}\ \text{kg} = 231\ \text{kg}$	**5**
(b)	Use of $\omega = \frac{2\pi}{T}$ $T = 228$ s	**(1)** **(1)**	Example of calculation $T = \frac{2\pi\ \text{rad}}{2.76 \times 10^{-2}\ \text{rad s}^{-1}} = 227.6\ \text{s}$	**2**
(c)	Use of $g = \frac{GM}{r^2}$ $M = 1.8 \times 10^{12}$ kg	**(1)** **(1)**	Example of calculation $M = \frac{gr^2}{G} = \frac{9.8\ \text{N kg}^{-1} \times (3.5\ \text{m})^2}{6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}} = 1.80 \times 10^{12}\ \text{kg}$	**2**

3 - (WPH11/5(IAL)_Winter_2025_Q3) - *Further Mechanics, Electric And Magnetic Fields*

	C is the correct answer (both fields can produce repulsive forces) A is not correct because both fields are radial B is not correct because both fields can exert attractive forces D is not correct because both fields obey an inverse square law for force	**1**

1 - (WPH11/5(IAL)_Summer_2024_Q11) - *Astrophysics And Cosmology, Electric And Magnetic Fields*

	EITHER ($V_{grav} = \frac{-GM}{r}$, so) gravitational potential $\propto \frac{1}{r}$ **Or** $V_{grav} = \frac{-GM}{r}$ and G and M are constant [Allow a graph or a description in words to describe an inverse relationship as long as potential equation is given] The equipotential surfaces become further apart with increasing distance (from Earth) **OR** Equal work needed to transfer a body from X to Y and from Y to Z (Mean) gravitational force is larger between X and Y, so distance moved must be smaller	**(1)** **(1)** **(1)** **(1)**	**2**

2 - (WPH11/5(IAL)_Winter_2025_Q3) - *Further Mechanics, Electric And Magnetic Fields*

	C is the correct answer (both fields can produce repulsive forces) A is not correct because both fields are radial B is not correct because both fields can exert attractive forces D is not correct because both fields obey an inverse square law for force	**1**

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