2025 H2 Physics P2 Solution

1	**(a)**	The distribution is not uniform with more mass loaded nearer to the left.	B1
	(b)	Resultant force on the boat is zero	B1
		Resultant moment about any pivot is zero	B1
	(c)	$T_1 + T_2 = 15000$	C1
		$15000(0.75) = T_2\,(2)$	
		$T_1 = 9400$ N	A1
		$T_2 = 5600$ N	A2
	(d)	Wd = 15000 (30)	B1
		P = 15000 (30)/12	
		= 37500 W	

2	**(a)**	The cube undergoes resonance when the driving frequency of the water wave equals the natural frequency of the oscillating system/cube.	B1
		There is maximum transfer of energy from the water wave to the cube/ The energy of the system/cube becomes a maximum and the system/cube oscillates with maximum amplitude.	B1
	(b)	$v = f\lambda$	
		$f = 2.0$ Hz	M1
		Substitute f = 2.0 Hz into $f = \frac{1}{2\pi}\sqrt{\frac{g}{l}}$	
		$l = 0.0621$ m	A1
	(c) (i)	Increase in wavelength results in decrease in driving frequency, thus driving frequency is not equal to natural frequency,	M1
		Amplitude decreases.	A1
	(ii)	Increase in mass results in an increase in *l*, and an decrease in natural frequency. Thus, driving frequency is not equal to natural frequency,	M1
		Amplitude decreases.	A1
	(d)	Drag force due to water on the cube causes damping.	B1
		Thus, maximum amplitude of oscillation occurs at a driving frequency 2 Hz, which is smaller than the natural frequency.	
		Since $f = \frac{1}{2\pi}\sqrt{\frac{g}{l}}$, a smaller value of *f* used in calculation results in a larger value of *l* calculated.	B1
		As such, the value determined in (b) is larger than actual measurement.	

3(a) Using $v = f\lambda$

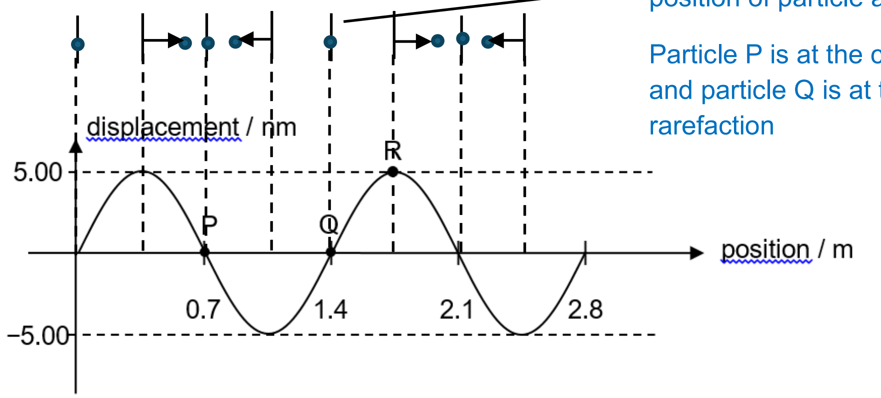
$$v = \frac{1}{4.0 \times 10^{-3}} \times 1.4$$ M1

$= 350 \text{ m s}^{-1}$ A1

(b)(i) **Particle R**

(As the particle is undergoing SHM, at the amplitude, the instantaneous velocity of the particle is zero). A1

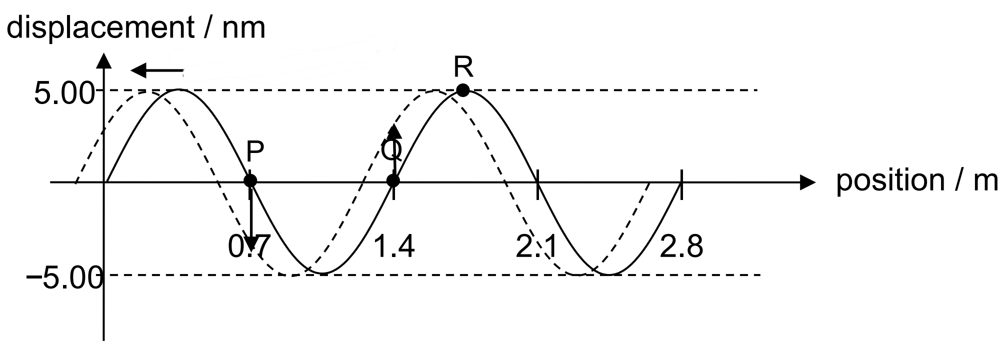
(b)(ii) **Particle Q** . A1



Vertical lines represent equilibrium position of particle along the wave.

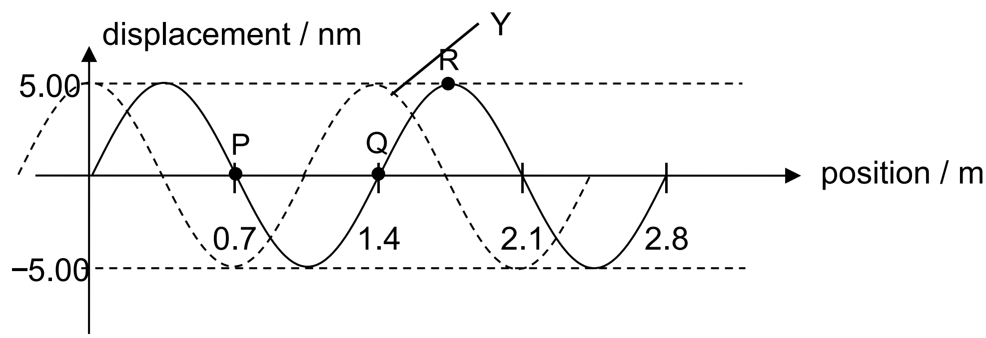
Particle P is at the centre of compression and particle Q is at the centre of rarefaction

(b)(iii) Displacement of article Q will be positive next instant. A1



(c)(i) Distance travelled by wave in 1 ms = vt = (350)(1×10^{-3}) = 0.35 m

The graph should have shifted to the left by 0.35 m. C1



A1

Award mark as long as one full wavelength is drawn with displacement at 5.00 nm at initial position.

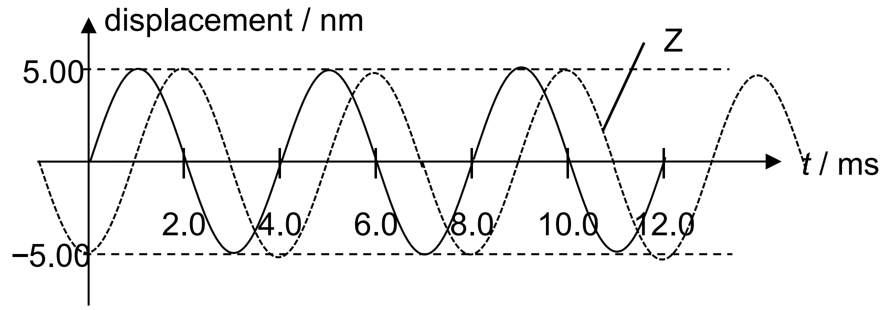
(c)(ii) Phase difference between particle R and S C1

$$\Delta\phi = \frac{\Delta x}{\lambda} \times 360^\circ = \frac{0.7}{1.4} \times 360^\circ$$

$$= 180^\circ$$

OR

Phase difference between particle Q and S is 90^o.



A1

4	**(a)**		1. Waves must meet π rad out of phase.	A1
			2. Waves must have equal amplitude.	A1
	(b)	**(i)**	Wavetrains from S_1 and S_2 are <u>coherent</u> and <u>superpose</u> at points along YZ.	C1
			When path difference is an integral multiple of λ, the waves meet in phase, <u>constructive interference</u> takes place to give a series of maxima.	C1
		(ii)	It decreased to one quarter of the original x (since $x = \lambda D/a$)	A1
		(iii)	The line YZ is not parallel to the slits	A1
			or the slits not normal to the (incident) microwaves	
		(iv)	Place a polariser in front of the transmitter and rotate through 90° OR rotate transmitter/detector through 90°.	M1
			If this causes minimal/zero signal at some angles, the wave is plane polarized.	A1
	(c)		Distance between two nodes = ½ λ = speed of detector / frequency of detection	C1
			= 10 / 1.5 = 6.7 mm	
			Hence, wavelength = 13 mm	C1
			f = c/λ = 3.00 x 10^8 / 13 x 10^{-3} = 2.3 x 10^{10} Hz.	A1
	(d)	**(i)**	White light diffracts after passing through the slits in the grating. For zeroth order maxima, each of the wavelengths in the white light travels the same path length/ zero path difference.	B1
			The amplitudes add up vectorially to produce a resultant white colour maxima	A1
		(ii)	wavelength λ of red light > wavelength blue light ($\lambda_{red} > \lambda_{blue}$)	B1
			For waves from any two adjacent slits, path difference is $d \sin\theta$, where d is the separation between the slits.	A0
			To produce a maxima for 1st order, path difference, dsin θ = 1 λ	
			Hence, maxima for different colors occurs at different angle θ , with red light at a larger angle	B1

5	**(ai)**		$V_{rms} = \frac{V_0}{\sqrt{2}} = \frac{170}{\sqrt{2}} = 120$ V	A1
	(aii)		$\omega = 2\pi/T = 314$ $T = 0.0200$ s	A1
	(b)	**(i)**	$\frac{V_S}{V_P} = \frac{N_S}{N_P}$ $\frac{V_S}{170} = \frac{3500}{2000}$ $V_S = 298$ V	C1

A1

(ii) $V_S = I_S R$ C1

$298 = I_S(130)$

$I_S = 2.288\text{ A}$

$\dfrac{I_P}{I_S} = \dfrac{N_S}{N_P} = \dfrac{3500}{2000}$ A1

$I_P = 4.00\text{ A}$

b iii $V_S = I_S R$ C1

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A1

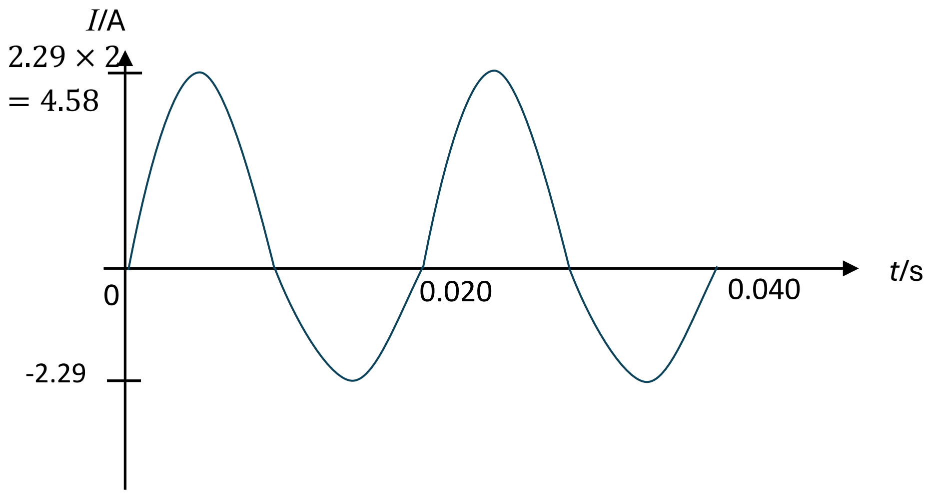
Power loss due to B1

Induced Eddy currents

Hysteresis los

Any possible causes

(c)



6 (a) (i) From Fig. 6.2, the current at t = 0.070 s is 1.500 A.

$n = \dfrac{3000}{0.15} = 20000$ M1

$B = \mu_0 n I = 4\pi \times 10^{-7} \times 20000 \times 1.500$ M1

$= 3.77 \times 10^{-2}\text{ T}$ A0

(ii) Using points (0.070, 1.500) and (3.80, 0.550) on the line in Fig. 5.2,

$$\frac{dI}{dt} = \frac{0.550 - 1.500}{0.380 - 0.070} = -3.0645 = -3.06$$ C1

According to Faraday's law,

$$\text{e.m.f.} = -\frac{d\Phi}{dt} = -\frac{d}{dt}(N_c B_s A_s)$$

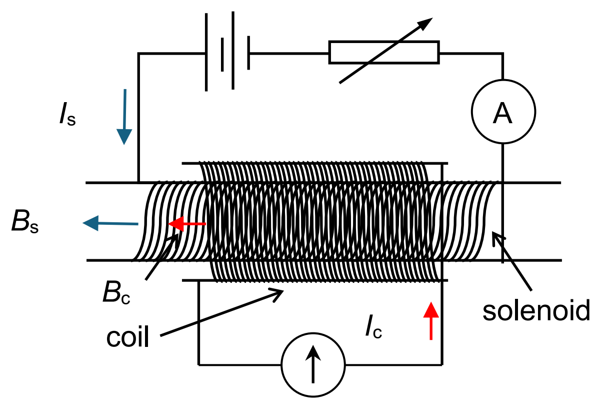
$$= -N_c A_s \frac{d}{dt}(\mu_0 n I)$$

$$= -N_c A_s \mu_0 n \frac{dI}{dt}$$

$$= -1500 \times 2.5 \times 10^{-4} \times 4\pi \times 10^{-7} \times 20000 \times (-3.0645)$$ C1

$$= 2.8882 \times 10^{-2} = 2.89 \times 10^{-2} \text{ V}$$ A1

(iii)



The current I_s in the solenoid flows from the positive terminal of the battery. By right-hand-grip rule, the magnetic flux density B_s produced points to the left. B1

Since I_s decreases, B_s also decreases so by Lenz's law, the induced magnetic flux density B_c in the coil must point to the left. B1

By right-hand-grip rule, the induced current I_c in the coil flows from left to right through the galvanometer. B1

7 **(a)** gravitational force exerted by Sun on Earth provides the centripetal force B1

$m r \omega^2 = GMm / r^2$

$r^3 = GM \times (T / 2\pi)^2$ C1

$r^3 = 6.67 \times 10^{-11} \times 2.0 \times 10^{30} \times (365 \times 24 \times 3600 / 2\pi)^2$ C1

1 AU = $r = 1.498 \times 10^{11}$ m

= 1.50×10^{11} m A1

(b)(i) The mass of the Sun is much bigger compared to the total mass of all the planets, and so their gravitational influence is small. B1

(b)(ii) To escape to infinity, Initial KE of object at Jupiter ≥ gain in GPE from Jupiter to infinity C1

$(1/2)mv^2 \geq 0 - (-GMm / r)$

$(1/2)\ v^2 \geq GM / r$ C1

$v^2 \geq (2 \times 6.67 \times 10^{-11} \times 2.0 \times 10^{30}) \ / (5.2 \times 1.50 \times 10^{11})$

$\boldsymbol{v_{\min} = 1.85 \times 10^4}$ **m s^{-1}.** A1

(b)(iii) According to Fig 7.3, the speed of Voyager 2 at Jupiter on 9 July 1979 was 10.5 km s^{-1} = 1.05×10^4 m s^{-1}, which is less than the escape speed of 1.85×10^4 m s^{-1} needed at that distance from the Sun. Hence, it was not travelling fast enough to escape to infinity. B1

(b)(iv) From Fig. 3, the speed of Voyager 2 increased from 10.5 km s^{-1} to 28.0 km s^{-1} during its interaction with Jupiter.

Hence, its gain in momentum = $\Delta p = p_f - p_i = mv_f - mv_i$ C1

$= 773\ (28.0 - 10.5) \times 10^3$

= 1**.35 × 10^7 kg m s^{-1}** A1

Velocity must be read to ½ square (1 dp)

(b)(v) Voyager 2 gains kinetic energy/momentum from Jupiter's orbital kinetic energy about the Sun. In a gravity assist, the spacecraft exchanges momentum/energy with the moving planet, the craft gains a tiny amount of the planet's orbital energy C1

(c)(i) Half-life, $t_{1/2}$ = 87.74 years

$A = A_0 \exp(-\lambda t)$ or $A = A_0 \exp(-\ln 2 \times t / t_{1/2})$ C1

$A = A_0 \exp(-\ln 2 \times 1/87.74)$

$A = A_0 \exp(-0.00790)$ C1

Activity remaining after one year is $A = 0.992\ A_0$

Hence, fractional decrease in activity in one year = 1 – 0.992 = 0.0079 = **0.79 %** A1

(c)(ii) $A = 0.623\ A_0$

Power output is proportional to the activity, so B1

$P = 0.623\ P_0$

$P = 0.623 \times 470 =$ **290 W** A1

(c)(iii) As spacecraft moved farther away, the intensity of the received radio waves had decreased, power received decreases (since power received = Intensity at that point x area of receiver.) B1

Hence, the total area of the receiving parabolic dish antenna needed to be increased so that the total power of the received waves will be large enough to be detected. B1

(d) In 1990, distance of Earth from Voyager 1 = 40.47 AU

Angular diameter of Earth = $\theta = d$ / D C1

= $(2 \times 6.4 \times 10^{6}) / (40.47 \times 1.50 \times 10^{11})$ = $\mathbf{2.1 \times 10^{-6}}$ **rad** A1