Answers to 2014 Prelim Paper 1 (H1 Physics)

1	C	**11**	B	**21**	D
2	C	**12**	C	**22**	A
3	B	**13**	A	**23**	B
4	D	**14**	B	**24**	D
5	B	**15**	A	**25**	D
6	A	**16**	A	**26**	A
7	C	**17**	A	**27**	C
8	B	**18**	D	**28**	A
9	B	**19**	D	**29**	C
10	D	**20**	D	**30**	A

MCQ 1: (C)

$P = I^2 R$

$\frac{\Delta P}{P} = 2\frac{\Delta I}{I} + \frac{\Delta R}{R}$

$= 2\frac{0.05}{2.50} + 0.02$

$= 0.06 = 6\%$

MCQ 2: (C)

$k = \frac{F}{rv}$

units of $k = \frac{N}{m \times ms^{-1}}$

$= \frac{kgms^{-2}}{m \times ms^{-1}}$

$= kgm^{-1}s^{-1}$

MCQ 3: (B)

$KE = \frac{1}{2}mv^2 = \frac{1}{2}(80)(10)^2 = 4000 \text{ J}$

MCQ 4: (D)

Vertical acceleration is equal to gravitational acceleration which is constant.

MCQ 5: (B)

$v^2 = u^2 + 2as$

$20^2 = 10^2 + 2a(100)$

$a = 1.5 \text{ m s}^{-2}$

MCQ 6: (A)

$$s = ut + \frac{1}{2}at^2$$

$$35 = 0 + \frac{1}{2}(9.81)t_1^2$$

$$50 = 0 + \frac{1}{2}(9.81)t_2^2$$

$$t = t_2 - t_1 = 0.52 \text{ s}$$

MCQ 7: (C)
Acceleration is the same for each block.
For the left most first block, T_A = ma
2nd block, T_B - T_A = ma, T_B = 2ma
3rd block, T_C - T_B = ma, T_C = 3ma
Hence, T_C is the greatest.

MCQ 8: (B)
Taking the balancing weight, the passenger car and the passenger as a system,
Using N2L, F_{net} = ma
640g – 520g – 80g = (640+520+80) a
a=0.316 m s^{-2}

MCQ 9: (B)
For elastic collisions, relative speed of separation = relative speed of approach

$v_1 - v_2 = u_2 - u_1$
$v_1 - v_2 = -u$
$v_2 = v_1 + u$ --- (1)

By COLM,
mu = mv_1 + 5mv_2 --- (2)

Solving (1) and (2),
v_1 = -0.67 u

MCQ 10: (D)
Area under force- extension graph = energy stored in the spring
Note that graph given is length vs force graph.

MCQ 11: (B)
Recall: To get spring constant, we need the gradient of load (Y-axis) against extension of spring (X-axis).

Note that the graph is length of spring (Y-axis) against load (X-axis).
Hence, from the graph given, the inverse of the gradient of the line would be the spring constant

MCQ 12: (C)
Using principle of moments,
Clockwise moment about pivot = Anticlockwise moment about pivot.

Hence Fx is always a constant, $Fx = k$

$$F \propto \frac{k}{x}$$

MCQ 13: (A)
By COE,
Gain in KE = Loss in GPE

KE just before ball strikes surface = initial GPE
$KE_1 = mgh_1$ --- (1)

KE just after ball strikes surface = final GPE
$KE_2 = mgh_2$ --- (2)

Taking the bottom of the ball as reference,
(2)/(1): $KE_2 = h_2 / h_1 (KE_1)$
$= 30/70 \times 0.80 = 0.34$ J

MCQ 14: (B)

$$F = \left(\frac{15}{30}\right)^2 1800$$

$$P = Fv = \left(\frac{15}{30}\right)^2 1800 \times 15$$
$$= 6750\ W$$

MCQ 15: (A)
For Alice to hear the music as loud as before, the intensity of the sound reaching her ears should remain the same.

$$\frac{P}{4\pi(15)^2} = \frac{0.75P}{4\pi(x)^2}$$
$$x = 13 \text{ m}$$

MCQ 16: (A)

Phase difference $= \dfrac{0.22 \times \sin 25^\circ}{1.7} \times 2\pi = 0.34$ rad

MCQ 17: (A)
From a node, through 15 antinodes, to another node is equivalent to 7.5 wavelengths.

$$\lambda = \frac{1.200}{7.5} = 0.160 \text{ m}$$

On the CRO, 5 consecutive crests represents 4 periods.

$$T = \frac{8.5}{4} \times \left(0.50 \times 10^{-3}\right) = 1.0625 \times 10^{-3} \text{ s}$$

$$v = f\lambda = \frac{1}{T}\lambda = 150 \text{ m s}^{-1}$$

MCQ 18: (D)
Option A: the points <u>between</u> P and R have difference amplitudes.
Option B: The phase difference between S and T is <u>exactly π</u> as they are in adjacent loops.
Option C: Distance between <u>P and Q</u> (not R) gives the wavelength.
Option D: It is possible to set up the <u>fundamental</u> frequency standing wave between P and Q.

MCQ 19: (D)
Initially the detector does not detect any light as the light from Q will not be able to pass through R since their axes of polarization are perpendicular.
When Q is rotated, some light will pass through Q from P as their axes of polarization are not perpendicular. Similarly, some light will pass through Q from P as their axes of polarization are also not perpendicular.
Eventually when Q is rotated through 90°, light from P will not be able to pass through Q anymore and the detector will once again detect no light.

MCQ 20: (D)
Direction of flow of electrons and protons both contributes to the conventional current

Net current = $(9.0 \times 10^{18})(1.6 \times 10^{-19})$= 1.44 A

MCQ 21: (D)
Let mass of tungsten be m_t and mass of copper be m_c
Let density of tungsten be d_t and density of copper be d_c

$$\frac{m_t}{m_c} = \frac{d_t \times V_t}{d_c \times V_c} = \frac{d_t \times A_t}{d_c \times A_c} \text{ since L is the same for both materials}$$

$$R = \frac{\rho L}{A}$$

Since R and L are the same, $\frac{A_t}{A_c} = \frac{\rho_t}{\rho_c} = 3$

Hence $\frac{m_t}{m_c} = \frac{1}{3}\left(\frac{d_t}{d_c}\right) = 3 \times 2 = 6$

MCQ 22: (A)

$$E = \frac{workdone}{\Delta Q} = \frac{4500}{0.5 \times 1000} = 9.0 \text{ V}$$

MCQ 23: (B)

$$P = I^2 R + I^2 r$$

$$\frac{4500}{1.0 \times 10^3} = (0.50)^2 (16) + (0.50)^2 r$$

$$r = 2\Omega$$

MCQ 24: (D)
Lamp Z is most likely faulty (fused), hence it forms a closed circuit across the bulb. The resistance across a short circuit is very small and thus yielding the <1.0 Ω reading in the resistance meter each time switch 2 is turned on.

MCQ 25: (D)
Electron is moving hence it will experience a magnetic force.

The magnetic force acting on the electrons are pointing downwards using Fleming's left hand rule. Hence over time, all electrons will accumulate at the bottom of the rod, resulting in a negative potential at the bottom and a positive potential at the top of the rod.
With this difference in potential, an electric field is set up within the rod, hence an electrostatic force will also be experienced.

MCQ 26: (A)
$F_E = F_B$
$qE = Bqv$

Independent of charge, independent of mass.

MCQ 27: (C)
B $\propto$ *I* (*n* remains the same)

When the solenoid length is halved, its resistance also decreases by half.

Using *V*=*IR*, with *V* being constant and *R* decreasing by half, *I* will double, hence *B* will double.

MCQ 28: (A)
K_{max} = 0 eV occurs when λ = 250 nm. Therefore, the threshold wavelength is 250 nm.

By photoelectric equation, $\frac{hc}{\lambda} = \Phi + K_{max}$

Hence,
$$\Phi = \frac{hc}{\lambda} - K_{max} = \frac{6.63\times10^{-34}(3.0\times10^{8})}{250\times10^{-9}} - 0$$
$$\Phi = 7.956\times10^{-19}\text{ J} = 4.97\text{ eV}$$

MCQ 29: (C)
In a heated gas, the atoms are excited and could be at 2.00 eV or 3.00 eV level.

Hence, as light passes both the cold and heated gases, the photons would be emitted when electrons transits from 3.00 eV →2.00eV, 3.00 eV →ground & 2.00 eV →ground.

Using, $E = \frac{hc}{\lambda}$

Transitions	Photon energy (eV)	Photon energy (Joules)	Photon wavelength (nm)
3.00 eV →2.00eV	1.00	1.6×10^{-19}	1240
3.00 eV →ground	3.00	4.8×10^{-19}	414
2.00 eV →ground	2.00	3.2×10^{-19}	622

MCQ 30: (A)
By de Broglie wavelength, $\lambda = \frac{h}{p}$

Momentum of the proton, $p = \frac{h}{\lambda} = \frac{6.63\times10^{-34}}{0.200\times10^{-9}} = 3.315\times10^{-24}\text{ kg m s}^{-1}$

KE of proton, $KE = \frac{p^2}{2m} = \frac{(3.315\times10^{-24})^2}{2(1.67\times10^{-27})} = 3.29\times10^{-21}\text{ J}$

Suggested Solutions to 2014 Prelim Paper 2 (H1 Physics)

Section A

1 **(a)** Taking up the slope as positive,

$a = g\sin\theta = -3.355$

$v^2 = u^2 + 2as$

$0 = 4^2 + 2(-3.355)(s)$

$s = 2.38$ m

$\frac{1}{2}mv^2 + mgh = \frac{1}{2}mu^2$

$0 + 9.81 \times d\sin 20 = \frac{1}{2} \times 4^2$ [M1]

$s = 2.38$ m / 2.4 m [A1]

(b) Determine the time taken for the block to reach the bottom of the ramp from the time it was projected.

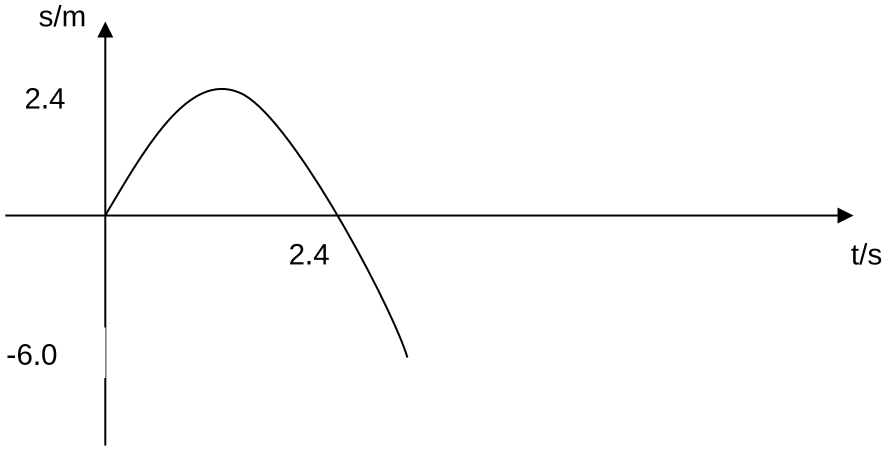
$s = ut + \frac{1}{2}at^2$

$-6 = 4t + \frac{1}{2}(-3.355)t^2$ [M1]

$1.6775t^2 - 4t - 6 = 0$

$t = 3.43$ s [A1]

(c)



Correct shape [B1]
Correct labels [B1]

2 **(a)** **(i)** Effective resistance due to AC and ADC, R\` = $\left(\frac{1}{6.0} + \frac{1}{12.0}\right)^{-1} = 4.0\Omega$ [M1]

Effective resistance due to AB and R\` = 4.0 + 6.0 = 10.0 Ω [M1]

Total effective resistance between BC = $\left(\frac{1}{6.0} + \frac{1}{10.0}\right)^{-1} = 3.75\Omega$ [A1]

(ii) Effective resistance across thermistor and filament lamp =

$$\left(\frac{1}{170}+\frac{1}{210}\right)^{-1}=93.9\Omega$$ [M1]

Using potential divider principle,

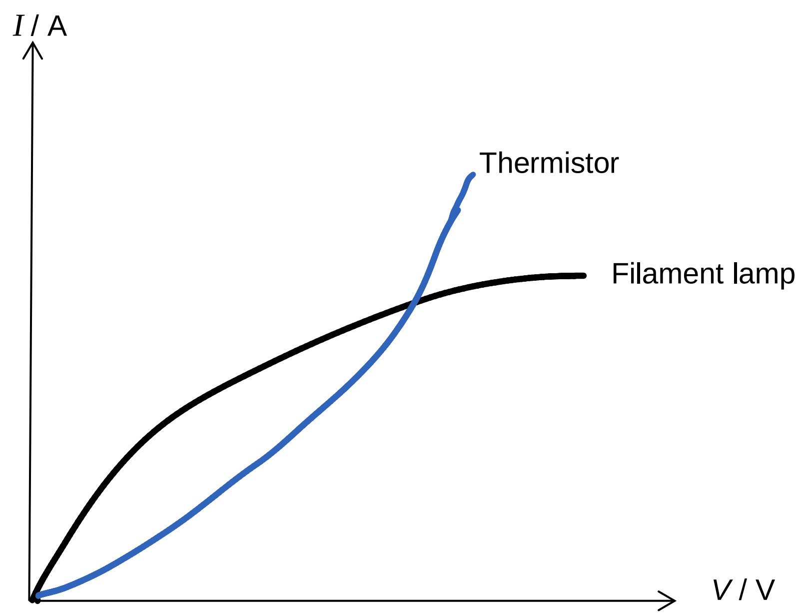
Voltmeter reading = $\left(\frac{93.9}{93.9+3.75}\right)15.0=14.4\text{V}$ [A1]

(If method is correct but calculation is wrong, M1 mark still given).

(iii) Power dissipated in the filament lamp =

$$\left(\frac{14.4^2}{210}\right)=0.987\text{W}$$ [A1]

(b) **(i)**



1mark for the correct shape and label of the thermistor I-V graph
1mark for the correct shape and label of the filament lamp I-V graph

The resistance of the device can be obtained from the ratio of potential difference and its corresponding current value read from a particular point on the graph. [A1]

(ii) The thermistor is made of semiconductor material such as silicon or germanium.
Increased p.d. across the thermistor results in an increased current which in turn, causes the temperature to rise. [M1]
As the temperature rises, the lattice ions vibrations increase and reduce

the drift velocity of the charged particles.

However, the effect of the increase in the number of free electrons and holes due to temperature increase is more significant than the reduction in drift velocity of the charged particles. [M1]

Hence, the resistance of the NTC thermistor decreases as temperature increases. [A1]

3 (a) (i) The direction of the compass needle is the resultant of the Earth's magnetic field and the field produced by the wire when current passes through it. [M1]

The direction of the Earth's magnetic field is given in Fig. 41b, pointing horizontally to the right. Hence in order to get the resultant field as shown, using Fig. 3.2, the magnetic field produced by the wire must be pointing upwards. [M1]

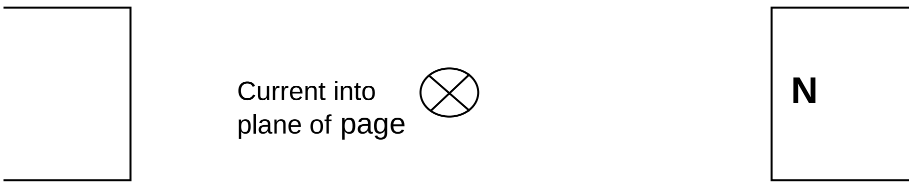
Using right hand grip rule, the current in the wire points out of the cardboard (or paper) [A1]

(ii)

$$B_{\text{with current}} = \frac{\mu_o I}{2\pi r} = \frac{4\pi \times 10^{-7}(4)}{2\pi(2.0\times10^{-2})} = 4.0\times10^{-5}\text{ T}$$ [M1]

$$B_{\text{w/o current}} = B_{\text{Earth}} = \frac{B_{wire}}{\tan 30^\circ} = \frac{4.0\times10^{-5}}{\tan 30^\circ} = 6.9\times10^{-5}\text{ T}$$ [A1]

(b) (i)



For the wire to just lift off, the resultant force acting on the wire must be zero. Hence with weight pointing vertically downwards, the magnetic force experience by the wire must point vertically upwards. [B1]

Using Fleming left hand rule, the right pole is North. [B1]

(ii) $BI\ell = mg$

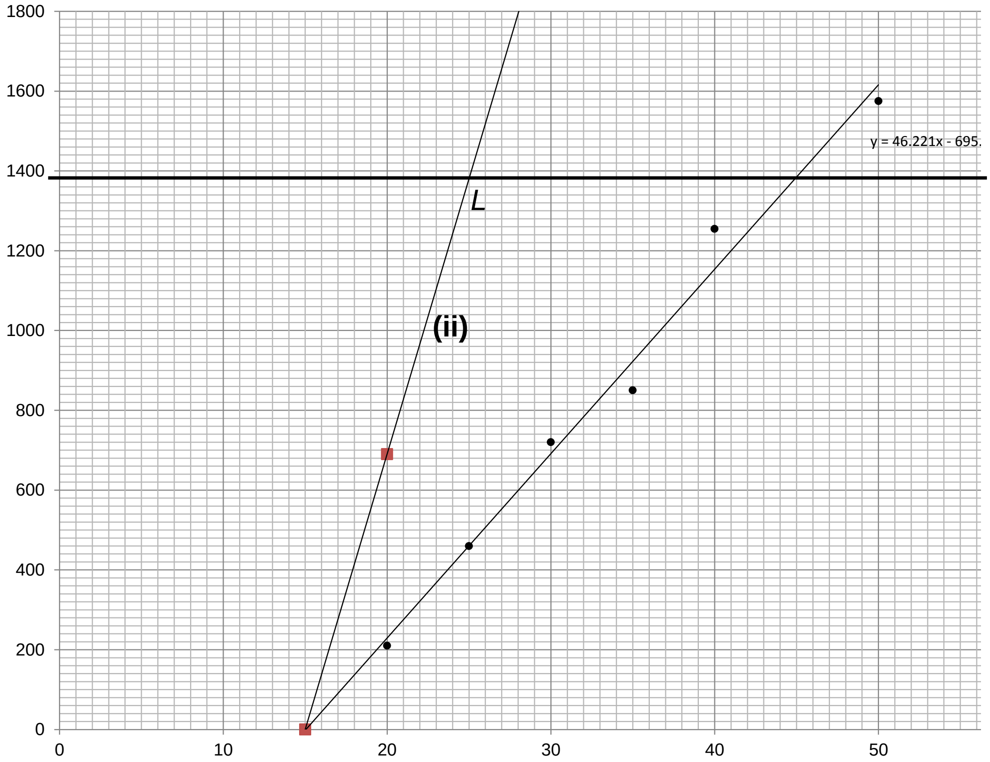
$$I = \frac{0.42(9.81)}{0.30(0.80)}$$

$$= 17\text{ A}$$ [B1]

(iii) The B field at any point is the resultant of the B field due to the magnet and the B field due to the wire. [M1]
The B field due to the magnet points from right to left and the B field due to the wire is in the clockwise direction.
At point X, both fields are pointing in opposite directions and at point Y, both field are pointing in the same direction to the left.

Hence, at point Y the magnitude of the magnetic field strength is greater. [A1]

4 **(a)** **(i)**



BFL: even scatter of points [B1]

(ii) Horizontal intercept = 15.0 m [B1]
(based on student's BFL)
Read off must be accurate to half a smallest square

(iii) Spring constant = gradient of the graph [M1]
= 46 N m^{-1} [A1]

(based on student's BFL)
Read off must be accurate to half a smallest square

(b) **(i)** Spring constant = 3 x 46 = 138 N m^{-1} [B1]

(iii) At lowest point, KE = 0

Let e represent the extension in the cable,
Loss in GPE = Gain in EPE
mg (15 + e) = ½ (138) e^2 [M1]

e = -9.8 (reject) or e = 28.3 m

Lowest point = 28.3 + 15 [M1]
= 43.3 m [A1]

(iv) $F_{net} = 0$
Horizontal line drawn at F = 130 x 9.81 = 1275 N

Intersection point labelled as L [B1]

(v) From point L to the lowest point, loss in kinetic energy (KE) and gravitational potential energy (GPE) is converted to gain in elastic potential energy (EPE). [B1]
Taking the lowest point as the reference point, the jumper's KE and GPE is converted to EPE at the lowest point. [B1]

Section B

5 (a) (i)

$$E = \frac{(93x10^3)(2.28)}{\pi(\frac{1.05x10^{-3}}{2})^2} = 2.4487x10^{11} Nm^{-2}$$ [M1]

$$\frac{\Delta E}{E} = 2\frac{\Delta d}{d} + \frac{\Delta l}{l} + \frac{\Delta\left(\frac{F}{e}\right)}{\frac{F}{e}}$$

$$\frac{\Delta E}{2.4487x10^{11}} = 2\frac{0.04}{1.05} + \frac{0.01}{2.28} + \frac{5}{93}$$ [M1]

$$\Delta E = 0.328958x10^{11}\ Nm^{-2}$$

$$E = (2.4 \pm 0.3) \text{ x } 10^{11}\ Nm^{-2}$$ [A1]

(ii)

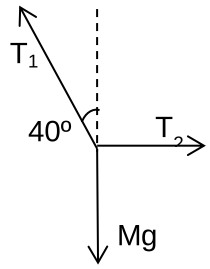
$$\frac{\Delta A}{A} = 2\frac{\Delta d}{d} = 2 \times \frac{0.04}{1.05} = 0.076$$

$$\frac{\Delta l}{l} = \frac{0.01}{2.28} = 0.0044$$

$$\frac{\Delta\left(\frac{F}{e}\right)}{\frac{F}{e}} = \frac{5}{93} = 0.054$$

Since the fractional uncertainty is the largest for diameter, [M1] (need to show evidence from previous part of otherwise)
The diameter is the most significant uncertainty in calculating E. [A1]

(b) (i) Since both masses are similar and both strings are symmetrical, consider the forces at one of the connections where string 1 and 2 meet.



Resolving forces vertically,
$T_1 \cos 40^o = Mg$

Resolving forces horizontally,
$T_1 \sin 40^o = T_2$ [M1] for both correct expressions

$\tan 40^o = T_2 / Mg$

$M = 45 / 9.81 \tan 40^o$ [M1]
$= 5.47$ kg [A1]

(ii) $T_1 \sin 40^o = T_2$
$T_1 = 45 / \sin 40^o$
$= 70.0$ N [M1]
Not possible as the tension in string 1 would be beyond the breaking strength of 65 N [A1]

(c) (i) When the collision <u>occur in the same straight line without any deviations to the original straight path</u> [B1]
and the <u>total kinetic energy of the isolated system is conserved</u> [B1]

(ii)

1. Using conservation of momentum, taking upward as positive,

$m_t u_t + m_r u_r = m_t v_t + m_r v_r$
$(0.057)(-6.5) + (0.780)(5.2) = 0.058\ v_t + (0.780) v_r$
$0.058\ v_t + (0.780) v_r = 3.69$ [B1]

2. Relative speed of approach = relative speed of separation,

$u_r - u_t = v_t - v_r$
$v_t - v_r = 5.2 - (-6.5) = 11.7$ [B1]

3. Solving the two equations simultaneously,

$v_t = 15.3$ m s^{-1} [B1]
$v_r = 3.59$ m s^{-1} [B1]

(iii) $\Delta p = m\left(v_f - v_i\right)$
$= (0.057)(15.3 - (-6.5))$ [M1]
$= 1.24$ N s [A1]

(iv) Area under F - t graph $= \Delta p$

$0.5\ F_{max}\ (0.040) = 1.2426$ [M1]

$F_{max} = 62.1$ N [A1]

6 **(a)** **(i)** **1.** Diffraction refers to the bending or spreading out of waves when they travel through a small opening or when they pass round a small obstacle. [B1]

2. Interference refers to the superposing of two or more coherent waves to produce regions of maxima and minima in space, according to the principle of superposition [B1]

3. Coherence refers to having a constant phase difference and same frequency (between waves/sources/particles). [B1]

(ii) Any two [B1 each]:

1. The waves must be coherent.
2. The waves must have approximately the same amplitude.
3. The waves must be unpolarised or polarised in the same plane (for transverse waves).

(b) **(i)** Since the two radio waves are in phase, along centre-line,
path difference is always zero [B1]
Hence constructive interference occurs.

(ii) Radio waves have long wavelengths, hence the [A1]
anti-nodal lines will be far apart enough for the ship to differentiate [M1]

(iii) Since the intensity of each individual wave is inversely proportional to the square of the distance, the intensity of each individual wave will increase as the ship goes nearer, hence the resultant intensity will increase. [M1]
OR
Since the amplitude of each individual wave is inversely proportional to distance, the amplitude of each individual wave will increase as the ship goes nearer, hence the resultant amplitude of the superposed wave will increase. As intensity is proportional to the square of the amplitude, intensity increases.[M1]

Hence, the intensity of the resultant increases as the ship approached the gate [A1]

(c)

$$\lambda_1 = \frac{c}{f_1} = \frac{3.0\times10^8}{23.5\times10^6} = 12.77 \text{ m} \quad \text{[C1]}$$

$$\text{Path difference } = \sqrt{(895)^2 + \left(250+\frac{95}{2}\right)^2} - \sqrt{(895)^2 + \left(250-\frac{95}{2}\right)^2} \quad \text{[M1]}$$

$= 25.527$ m

$\approx 2\lambda_1$ [A1]

Since the path difference is approximately $2\lambda_1$, the ship is on an anti-nodal line.

Note: using $x = \frac{\lambda D}{a}$ will earn no credit.

(d) **(i)** If ship is on the central anti-nodal line,
it should detect maximum signals from both frequencies / the maximum signal will be stronger [B1]
OR
If ship is on wrong anti-nodal line,
only one of the frequencies will show a strong signal. [B1]

(ii) Higher orders of maxima from both frequencies may still coincide/overlap [B1]
Hence the ship could still detect maximum signals from both frequencies even though it is not on the central anti-nodal line.

(e) **(i)**

$$I = \frac{P}{A}$$

$$= \frac{2.4 \times 10^{-11}}{0.53 \times 10^{-4}} \quad \text{[B1]}$$

$$= 4.53 \times 10^{-7} \text{ W m}^{-2}$$

$$= 4.5 \times 10^{-7} \text{ W m}^{-2} \quad \text{[A0]}$$

(ii)

$$I = \frac{P}{A}$$

$$P = \left(4.53 \times 10^{-7}\right)\left[4\pi\left(15000\right)^2\right] \quad \text{[M1]}$$

$$= 1280 \text{ W or } 1270 \text{ W} \quad \text{[A1]}$$

(f) Advantage:
Any one [B1]:
- Can still work under low visibility conditions
- Use of detector to align ship is more reliable than using visual inspection (or human judgement)

Disadvantage:
Any one [B1]:
- Possible interference of signals from other sources (e.g. radio stations, telecommunication base stations, etc)
- It is more costly to install the emitters as well as receivers on every ship.

7 **(a)** **(i)** The work function Φ of the surface is defined as *minimum* amount of the work necessary to remove a *free* electron from the *surface* of the material. [B2]

(ii) By photoelectric equation, $\frac{hc}{\lambda} = \Phi + K_{max}$

For any photo-electric emission to occur, $\frac{hc}{\lambda} \geq \Phi$ **[B1]** – this written explanation is needed to get marks.

For wavelength of 400 nm, $\frac{hc}{\lambda} = \frac{6.63\times10^{-34}(3.0\times10^{8})}{400\times10^{-9}} = 4.97\times10^{-19}\ \text{J} = 3.11\ \text{eV}$ **[B1]**

For wavelength of 700 nm, $\frac{hc}{\lambda} = \frac{6.63\times10^{-34}(3.0\times10^{8})}{700\times10^{-9}} = 2.84\times10^{-19}\ \text{J} = 1.78\ \text{eV}$

Since 3.11 eV > 2.26 eV and 3.11 eV > 1.88 eV,
and 1.78 eV < 1.88eV < 2.26 eV < 3.68 eV **[B1]**- for method only

Therefore, the possible combinations of light and metal surface are:

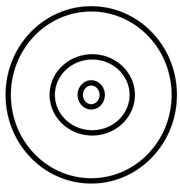
1) Wavelength of 400 nm and potassium
2) Wavelength of 400 nm and caesium **[B1- getting both correct]**

(iii) Student's claim is not valid. [A1] Intensity of light only affects the rate of photons incident on the target metal. Each photon energy $\frac{hc}{\lambda}$ remains the same for the same monochromatic light. [B1]

By the photoelectric equation, $\frac{hc}{\lambda} = \Phi + K_{max}$
the maximum kinetic energy of the emitted electrons remains unchanged if the target metal remains the same.

(b) **(i)** If the electrons behave as particles, a central bright spot would be observed on the screen. [A1]

(ii) Pattern observed:



The electrons behave as wave and the pattern observed would be concentric rings of particles with increasing distances away from centre. [A1]

(iii) Momentum of the electrons = mv = 9.11 x 10^{-31} x 8.5 x 10^{6} = 7.74 x 10^{-24} kg m s^{-1}
Hence, de Broglie's wavelength,

$$\lambda = \frac{h}{p} = \frac{6.63\times10^{-34}}{7.74\times10^{-24}} \quad [\text{M1}]$$

$$\lambda = 8.57\times10^{-11}\ \text{m} \quad [\text{A1}]$$

(c) **(i)** **1.**

$$E = \frac{hc}{\lambda} = \frac{6.63\times10^{-34}\times3.00\times10^{8}}{255\times10^{-9}}$$

$$E = 7.80\times10^{-19}\ \text{J} \quad [\text{B1}]$$

2.
Output power, P = 52% of 25 W = 13 W **[M1]**

Hence, $P = \frac{\text{Total Energy}}{\text{time}} = \frac{nhf}{t}$, where n is the number of photons

number of photons emitted per second

$$\frac{n}{t} = \frac{P}{hf} = \frac{P}{h\frac{c}{\lambda}} = \frac{13}{6.63\times10^{-34}\ \frac{3.00\times10^{8}}{255\times10^{-9}}}$$ **[M1]**

$$\frac{n}{t} = 1.67\times10^{19}$$ **[A1]**

(ii)

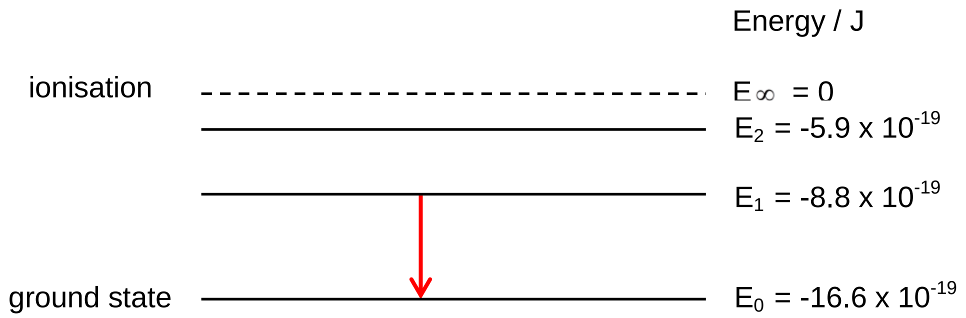


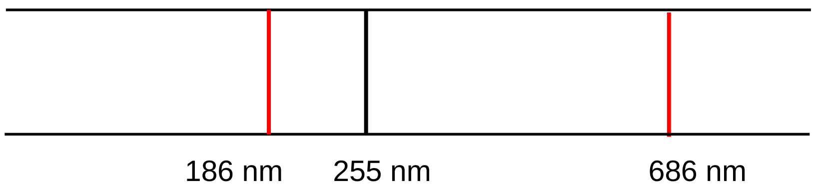
Fig 7.3

[B1]

(iii) Wavelength of 255 nm is in the ultraviolet region. Hence, there is no illumination of light.

[B1] Accept λ is too small or λ is not within the range of 400 nm and 700 nm of visible light.

(iv)



B1- for labelling 186 nm and 686 nm correctly
B1- for showing 186 nm closer to 255 nm line than 686 nm line