National Junior College 2022 Preliminary Examination

9749 H2 Physics

Paper 1

Answer Key

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

Suggested Solutions

1 **(B)**

Mass of sprinter = 65 kg

Speed of sprinter = 24 km h^{-1} = 6.7 m s^{-1}

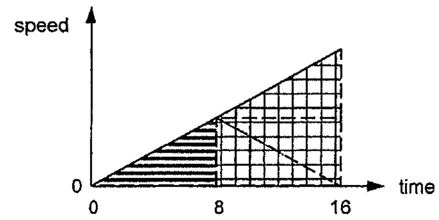
KE = 1500 J

2 **(D)**

3% of 327.66 = 9.8… = 10 m s^{-1}

3 **(C)**

[Method 1]



ratio = 3 parts / 1 part = 3

[Method 2]

Between 0 and 8 s, distance travelled $= 0 \times 8 + \frac{1}{2}a(8)^2 = 32a$ and speed $= 0 + a(8) = 8a$

Between 8 s and 16 s, distance travelled $= 8a \times 8 + \frac{1}{2}a(8)^2 = 96a$

Ratio $= 96a/32a = 3$

4 **(B)**

horizontal velocity after 4 s $= 35\cos 40° = 26.8$

vertical velocity after 4 s $= 35\sin 40° + (-9.81)(4.0) = -16.7$

speed after 4 s $= \sqrt{(35\cos 40°)^2 + (35\sin 40° - 9.81 \times 4)^2} = 32\ m\,s^{-1}$

5 **(C)**

F – f = ma

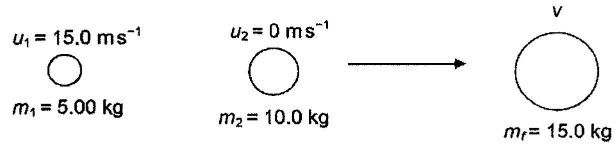
mg sin 15° – f = ma, thus

mg sin 20° – f = 2ma

f = mg (sin 20° – 2 sin 15°)

f = 0.86 N

6 **(B)**



Using conservation of momentum,

$m_1u_1 + m_2u_2 = m_fv$

$5.00(15.0) + 10.0(0) = 15.0(v)$

$v = 5.00$ m s^{-1}

Loss of kinetic energy $= \frac{1}{2}m_1u_1{}^2 - \frac{1}{2}m_fv^2$

$= \frac{1}{2}(5.00)(15.0)^2 - \frac{1}{2}(15.0)(5.00)^2$

$= 375$ J

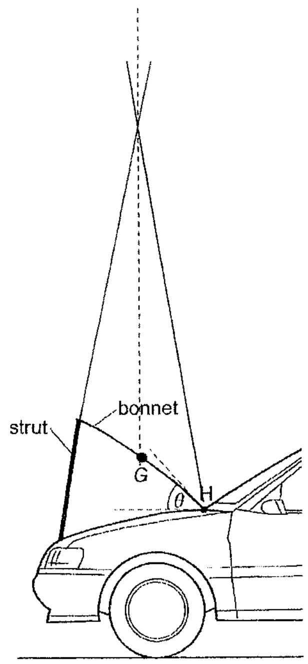
7 **(D)**

Pressure of oxygen = atm pressure + pressure of mercury

= 1.01 x 10^5 + 1.52(13.6x10^3)9.81 = 3.038 x 10^5 Pa

$\frac{\text{pressure of oxygen}}{\text{pressure of atmosphere}}$ = 3.038 x 10^5/1.01 x 10^5 = 3

8 (C)



9 (D)

Power = Work done/time = Fs/t = Fv

10 (C)

F = mrw^2 = (2)(5)(2π/3)^2 = $\frac{40\pi^2}{9}$ N

11 (C)

Let third particle be x from M_1.

$$\frac{GM_1m}{x^2} = \frac{GM_2m}{(d-x)^2} \Rightarrow \frac{x}{\sqrt{M_1}} = \frac{d-x}{\sqrt{M_2}} \Rightarrow x = \frac{d\sqrt{M_1}}{\sqrt{M_1}+\sqrt{M_2}}$$

12 (D)

Gravitational potential at Y = $\frac{GM}{2L} = \frac{1}{2} \times \frac{GM}{L} = \frac{1}{2} \times (-8) = -4\ kJ\ kg^{-1}$

Change in gravitational potential from X to Y = $(-4) - (-8) = 4\ kJ\ kg^{-1}$

Change in gravitational potential energy of 2 kg moved from X to Y = $2 \times 4 = 8\ kJ$

13 (B)

There is still heat flow, but the net heat flow is zero.

14 (D)

A: $pV = nRT \Rightarrow T \propto pV$, $(pV)_A = 8000$, $(pV)_B = 18000$, so temp of B > A, so internal energy changes

B: gas expands, so work is done by gas

C: From A, average k.e. for B > A

D: $q = \Delta U - w = +ve - (-work\ done\ by\ gas) > 0$

15 (B)

A: only true for ideal gas system

C: During change of phase, i.e boiling, internal energy increased but temperature remained constant.

D: U = KE + PE

16 (A)

$F = -\frac{\Delta E_p}{\Delta r} = -gradient\ of\ E_p - r\ graph$

17 (B)

$v = f\lambda$

$\lambda = \frac{320}{400} = 0.80\ m$

$\frac{\Delta\phi}{2\pi} = \frac{0.2}{0.8}$

$\Delta\phi = \frac{\pi}{2} rad$

18 (A)

Path S_2P is 5.0 m

p.d. = 5.0 – 3.0 = 2.0 m = 1 λ

Since the source starts antiphase and has a path difference of 1 wavelength, they meet destructively to give 0 amplitude.

19 (C)

When one end is closed,

L = ¼ λ

V = fλ

$f = \frac{v}{4L}$

When both ends are opened,

L = ½ λ

V = f'λ

$f' = \frac{v}{2L} = 2f$

20 (A)

field strength towards –Q on top left

field strength towards –Q on top right

field strength towards –Q on bottom left

So, resultant field strength towards top left

21 (B)

Positive charge experience upward electric force to balance the weight. The lower plate at higher potential than the top plate.

When *V* is decreased, P falls towards the lower plate.

–Gravitational potential energy will decrease.

–P gains electric potential moving towards lower plate, so gain electric potential energy

When *V* is increased, P rises towards the upper plate.

–Gravitational potential energy will increase.

–P losses electric potential moving towards upper plate, so loses electric potential energy

22 (D)

For closed circuits, terminal p.d. is lower when there is internal resistance in the source (non-ideal).

23 (C)

At X, voltmeter measure emf of battery.

At Y, voltmeter measure emf of battery. Voltmeter and lamp is connected in series.

At Z, it is a open circuit. Voltmeter reads 0 V.

24 (A)

N-pole of magnet experience a force in the same direction of field line.

S-pole of magnet experience a force in the opposite direction of field line.

Magnet will turn anticlockwise.

Field line of closer spacing indicates higher magnetic field strength. Force at S > force at N. So component of resultant force to the left and magnet accelerates left.

25 (C)

Average induced e.m.f = 2.1 (610 -120) x 10^{-4} / (16 x10^{-3}) = 6.4 V

26 (C)

T = 4 x 5 x 10^{-3} = 20 ms

$\omega = \frac{2\pi}{T} = \frac{2\pi}{20x10^{-3}}$ **= 314 =310**

27 (C)

energy of electron $E = eV$

energy of electron converted to a single photon $E = hf = \frac{hc}{\lambda_0} \Rightarrow \lambda_0 = \frac{hc}{eV} \Rightarrow \lambda_0 \propto \frac{1}{V}$

ratio $= \frac{(\lambda_0)_{6\,kV}}{(\lambda_0)_{8\,kV}} = \frac{8}{6} = 1.3$

28 (A)

$\Delta p \Delta x = h \Rightarrow \Delta p = \frac{6.63\times10^{-34}}{1.00\times10^{-10}} = 6.63 \times 10^{-24}\ kg\ m\ s^{-1}$

29 **(C)**

ratio of diameter of nucleus to atom should be small for most of the alpha particles to pass through undeflected.

30 **(A)**

alpha: few cm of air, about 1 mm of aluminium

beta: few mm of aluminium (about 5 mm)

gamma: a few cm of lead, thus several more cm of aluminium

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Paper 2

1 **(a)** **(i)** $-8.75 = (15.0 \sin 60°)\, t + ½\,(-9.81)\, t^2$ M1
$8.75 = (-15.0 \sin 60°)\, t + ½\,(9.81)\, t^2$ (M1)

solving t = 3.21 s A0

(ii) range of projectile = (15.0 cos 60°) (3.21) = 24.075 m M1

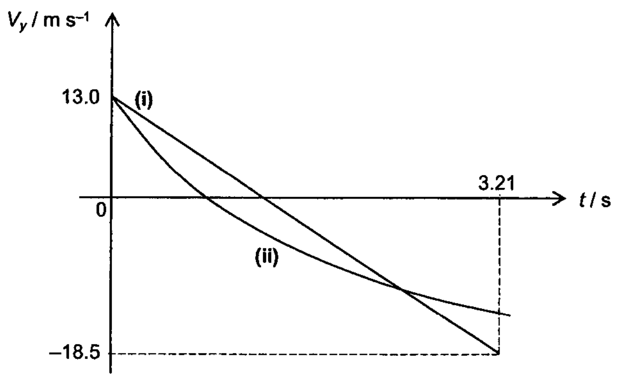
distance travelled by ship = 0.450 × 3.21 = 1.4445 m M1

D = 24.075 + 1.4445 = 25.5 m A1

(b) horizontal component of air resistance causes horizontal deceleration M1

so range of projectile shorter and D will be shorter A1

(c)



(i) straight line with negative gradient with final speed > original speed M1

label initial speed on y-axis and time of flight on x-axis A1

(ii) correct trend for graph (ii) M1

velocity = 0 at time earlier than **(i)** A1

2 **(a)** **(i)** force proportional / equal to rate of change of momentum (Newton II) M1

force on (block) A equal and opposite to force on (block) B (Newton III) M1
(Do not award this mark if the general definition of third law is given.)

equal magnitude of forces and collision time for A and B hence change in momentum same magnitude A1

opposite forces hence change in momentum opposite A1
(This mark is awarded only if "opposite forces" is explicitly linked to direction of change in momentum.)

(ii) if both blocks at rest, magnitude of change in momentum of A = (–)1.2M AND change in momentum of B = 0.25M M1

not equal hence not possible A1

(b) **(i)** *either* $3M \times 0.40 + M \times (-0.25) = 3M \times 0.20 + Mv$ (conservation of momentum)
or $3M \times (0.20 - 0.40) = -M \times (v + 0.25)$ M1

v = 0.35 m s^{-1} A1

(ii) *either* show total kinetic energy after < total kinetic energy before collision

or show relative speed of approach ≠ relative speed of separation M1

inelastic A1

BP~919

3 (a) (i) point which weight of ship — M1

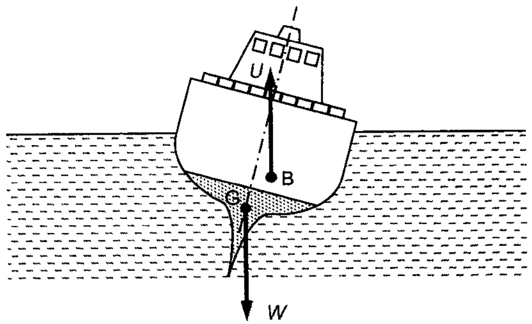
appears / seems to act — A1

(ii) water pressure on lower surface greater than air pressure on upper surface of ship — B1

(b) upthrust = weight
$1030\,V \times g = 2.20 \times 10^8 \times g$ — C1

volume = $2.14 \times 10^5\ \text{m}^3$ — A1

(c) (i) vertically downward arrow for *W* at G, vertically upward arrow for *U* at B and length of *W* and *U* approximately equal — B1

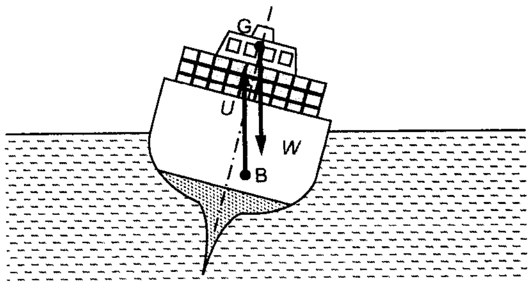


(ii) weight (or *W*) and upthrust (or *U*) forms a couple — M1

which gives anticlockwise torque (or moment) — A1

to right / correct the roll / tilt of the ship

(d) labelled weight through higher c.g. and labelled upthrust that produce overturning torque — B1



weight and upthrust forms a couple that give clockwise torque (or moment) to overturn ship — B1

[Turn over

4 (a) (i) effective resistance across BN = $\left(\frac{1}{2R}+\frac{1}{R+R}\right)^{-1} = R$

effective resistance across AM = $\left(\frac{1}{2R}+\frac{1}{R+R_{BN}}\right)^{-1} = \left(\frac{1}{2R}+\frac{1}{R+R}\right)^{-1}$ — M1

$= R$ — A0

or effective resistance across AM = $\left(\frac{1}{2R}+\frac{1}{R+\left(\frac{1}{2R}+\frac{1}{R+R}\right)^{-1}}\right)^{-1}$ — (M1)

(ii) use potential divider principle, $V_{AM} = \frac{R}{R+R} \times V = \frac{1}{2}V$ — M1

$V_A - V_M = V_A - 0 = V_{AM}$, so $V_A = \frac{1}{2}V$ — A1

(iii) $V_D = \frac{1}{2}V_C = \frac{1}{2}\times\frac{1}{2}V_B = \frac{1}{4}\times\frac{1}{2}V_A = \frac{1}{8}\times\frac{1}{2}V$ — C1

$V_D = \frac{1}{16}V$ — A1

(b) *either* $R_P = \frac{6}{6\times10^{-3}}$ (= 1000 Ω) — C1

$R_Q = \frac{6}{3\times10^{-3}}$ (= 2000 Ω) — C1

$R_{MN} = \left(\frac{1}{1000}+\frac{1}{2000}\right)^{-1} = 667\ \Omega$ — A1

or p.d. across MN = 6 V — (C1)

total current = 6 + 3 = 9 mA — (C1)

$R = \frac{6}{9\times10^{-3}} = 667\ \Omega$ — (A1)

5 **(a)** **(i)** region of space which a force is felt/experienced — B1

(ii) explanation that relates field strength to the closeness of lines — B1

(b) force on the magnet is downward — B1

force on current upwards by Newton's third law — M1

magnetic field directed towards P, P is South — A1

(c) **(i)** arrow from below foil to above the foil — B1

(ii) centripetal force of charged particle in circular motion provided by magnetic force
$\frac{mv^2}{r} = Bqv \Rightarrow mv = Bqr \Rightarrow$ momentum $\propto$ radius — C1

ratio = 5.7 / 7.4 = 0.77 — A1

6 **(a)** **(i)** ${}^{220}_{86}Rn \rightarrow {}^{216}_{84}Po + {}^{4}_{2}He + \gamma$

total proton and nucleon numbers equal on both sides — B1

equation include photon — B1

(ii) 1.0 MeV = 1 × 10^6 × 1.6 × 10^{-19} = 1.6 × 10^{-13} J — A1

(iii) **1.** energy released
= 6.29 MeV + 0.55 MeV (= 6.84 MeV = 1.094 × 10^{-12} J) — C1

$E = mc^2$
m = 1.094 × 10^{-12} / (3 × 10^8)^2 = 1.2 × 10^{-29} kg — A1

2. $E = hf = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{E}$
wavelength
= (6.63 × 10^{-34} × 3 × 10^8) / (0.55 × 1.6 × 10^{-13}) — M1

= 2.3 × 10^{-12} m — A1

(b) **(i)** N_0 is initial number of C-14 atoms, N_t is number of C-14 atoms now and N_{12} be number of C-12 atoms. So
$N_t = N_0 \exp\left(-\frac{\ln 2}{t_{1/2}} t\right)$ — C1

$\frac{N_t}{N_{12}} = \frac{N_0}{N_{12}} \exp\left(-\frac{\ln 2}{t_{1/2}} t\right)$
$\frac{1}{8.6\times10^{10}} = \frac{1}{3.3\times10^{10}} \exp\left(-\frac{\ln 2}{5700} t\right)$ — C1

t = 7900 years — A1

(ii) **1.** mass of a Carbon-14 ion different from Carbon-12 ion — B1

same magnetic force on each atom because they have same speed and charge — B1

so, radius of curvature of path of each type of ion in magnetic field is different

2. method enables determination of amount of Carbon-14 exactly — B1

instead of measuring the radioactivity which is probabilistic in nature — B1

7 (a) A photon is a quantum (or packet/ discrete bundle) of electromagnetic radiation (energy) B1

Each quantum has energy equal to *hf* where *h* is Planck constant and *f* is the frequency of the electromagnetic radiation B1

(b) (i) 1. $E_i = E_s + \frac{1}{2}mv^2$

2. $p_i = p_s \cos\theta + mv\cos\phi$

(ii) electron gain kinetic energy after collision, so scattered photon has lower energy than incident photon (refer to **(b)(i)1.**) B1

energy of photon inversely proportional to wavelength M1

so, wavelength of scattered photon larger than incident photon A1

(c) calculation for Δλ M1

λ_i / 10^{-12} m	λ_s /10^{-12} m	θ / °	Δλ / 10^{-12} m
191.92	193.27	57	1.35
153.30	154.65	57	1.35
965.04	966.84	75	1.8

valid conclusion comparing λ_i, θ and Δλ for the three sets of data e.g. A1
- compare first two sets of data, Δλ independent of incident photon wavelength for same scattering angle
- compare third set of data with the first two, Δλ dependent on incident photon wavelength for different scattering angles

(d) $\cos 70° = 0.342$, $\cos 75° = 0.259$, $\cos 80° = 0.174$ C1

either $\Delta(\cos\theta) = 0.342 - 0.259 = 0.08$
or $\Delta(\cos\theta) = 0.259 - 0.174 = 0.09$
or $\Delta(\cos\theta) = \frac{1}{2}(0.342 - 0.174) = 0.08$ C1

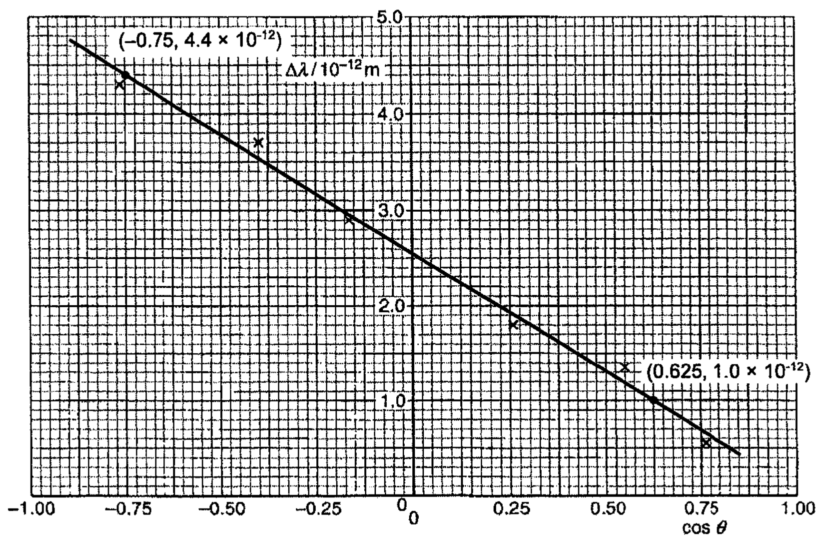
$\cos\theta = 0.26 \pm 0.08$ (or ± 0.09) A1

(e) (i) line of best fit assessed by even distribution of points either side of line along full length B1

(ii) [Method 1]
$\Delta\lambda = k(1 - \cos\theta) = -k\cos\theta + k$, so best fit straight line of Δλ against $\cos\theta$ gives M1

gradient equal $-k$ and y-intercept equal k A1

[Method 2]
obtain values of Δλ and $\cos\theta$ from a point on the best fit straight line and substitute into $\Delta\lambda = k(1 - \cos\theta)$ to calculate for k. B1



(iii) read-offs accurate to half a small square in both the x and y directions, gradient calculated correctly using $\frac{\Delta y}{\Delta x}$ and sign of gradient matches graph C1

$k = -$gradient and with unit m A1

OR

$k = y$-intercept and with unit m (M1)

precision of y-intercept to half the smallest square (A1)

OR

Substitute Δλ and $\cos\theta$ from a point on the line into $\Delta\lambda = k(1 - \cos\theta)$ (C1)

k calculated correctly and with unit m (A1)

($k \approx 2.5 \times 10^{-12}$ m)

(f) binding energy of electron less than / about $\left(\frac{10}{30000} \times 100\% =\right)$ 0.03% of energy of photon M1

photon energy >> binding energy so assumption of free electrons is valid / justified A1

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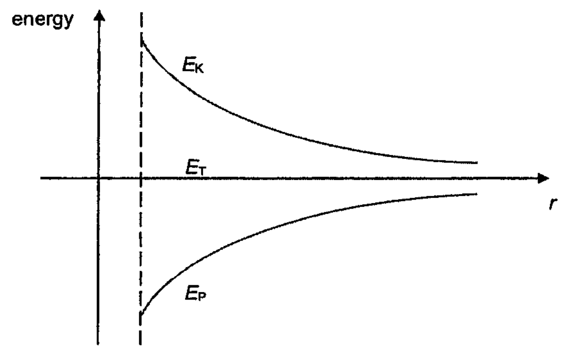
Paper 3

Suggested Solution

Section A

1 **(a)**



E_K positive and decreasing, not touching x-axis B1

E_P (roughly, but not too far off) symmetrical to E_K B1

E_T clearly shown (visibly or written in text) on the x-axis B1

(b) **(i)** Kinetic energy lost equals the gain in gravitational potential energy when object of mass m moves from the surface of Earth to infinity
$\frac{1}{2} mv^2 - 0 = 0 - (-GMm / R)$ B1

$v^2 = 2GM / R$

(ii) gravitational field strength at the surface of planet $g = GM / R^2$ equals the acceleration of free fall at the surface of planet B1

from **(i)**, $v^2 = 2\,(GM / R^2) \times R$ M1

$v^2 = 2gR$ A0

(c) **(i)** $3/2\ kT = \frac{1}{2} m v^2 = mgR$ C1

$T = 2mgR / 3k = (2 \times 6.6 \times 10^{-27} \times 9.81 \times 6.4 \times 10^6) / (3 \times 1.38 \times 10^{23})$ C1

$T = 2.0 \times 10^4$ K A1

(ii) temperature where all substances have minimum internal energy B1

2 **(a)** sum of random distribution of kinetic and potential energies of the molecules of the gas B1

no intermolecular forces for ideal gas M1

so no potential energy A1

therefore, internal energy equals to total kinetic energy of the molecules only

(b) **(i)** higher temperature increases r.m.s. speed and change in momentum of each molecule colliding with wall of container M1

increase volume reduces frequency of collision M1

force is product of frequency of collision and change in momentum which is constant when increase in change in momentum is balanced by reduction in frequency of collision A1

(ii) increase in internal energy $= \frac{3}{2}k(460 - 280) \times 1.2 \times 6.02 \times 10^{23}$ (= 2692 J) C1

heat supplied = $1.2 \times 0.032 \times c \times (460 - 280)$ (= $6.912c$) C1

heat supplied = increase in internal energy – work done on gas
$6.912c = 2692 + 1300$ (correct use of first law) C1

$c = 580$ J kg^{-1} K^{-1} or 578 J kg^{-1} K^{-1} A1

(c) constant volume so no work done B1

less thermal energy needed for same temperature rise, so smaller specific heat capacity B1

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3 (a) series of distinct coloured lines against dark background — B1

(b) photon emitted when electron changes from <u>higher to lower energy</u> — B1

energy of photon proportional to frequency — M1

each line represents photon of <u>specific / distinct</u> energy — A1

only transition between discrete energy levels leads to specific energies

(c) $\Delta E = 1.5 - 0.85$ (= 0.65 eV or 1.04×10^{-19} J) — C1

wavelength $= \frac{hc}{\Delta E} = \frac{6.63\times10^{-34}\times3\times10^{8}}{1.04\times10^{-19}} = 1.91 \times 10^{-6}$ m — M1

wavelength is longer than visible light / infrared, so not visible — A1

(d) (i) waves passing slits spread — B1

waves from each slit overlap — M1

with phase difference 360° / path difference λ — A1

(ii) angle of λ_1 maximum $= \tan^{-1}\frac{147-73.5}{240}$ (= 17.027° or 0.29718 rad) — C1

$\sin\theta_2 = \sin 17.027° \times \frac{654\times10^{-9}}{488\times10^{-9}}$ ($\Rightarrow \theta_2 = 23.106°$ or 0.40328 rad) — C1

$\frac{x-73.5}{240} = \tan 23.106°$ — M1

x = 175.9 cm — A1

4 (a) emission of electrons from a metal surface when surface is irradiated with electromagnetic radiation above threshold frequency — B1

(b) photon has energy dependent on frequency — B1

minimum energy required to remove electron from surface — B1

emission if energy of photon greater than minimum / work function / threshold energy — B1

so, threshold frequency exist

(c) (i) stopping potential is the minimum potential difference to stop the most energetic electrons from reaching the anode — B1

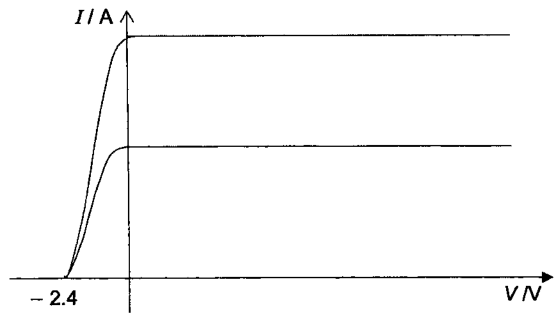
(ii) for positive values of V, all the electrons emitted from cathode will reach anode — B1

(iii) $E = \phi + eV_s$
$hf = 1.6 \times 1.6 \times 10^{-19} + 2.4 \times 1.6 \times 10^{-19}$ — C1

$f = 9.7 \times 10^{14}$ Hz — A1

(iv) same V_s — B1

saturated current doubled — B1



5 **(a)** **(i)** magnetic flux density decreases with distance from straight wire, so magnetic flux linkage in loop decreases as it falls — M1

e.m.f. induced in loop proportional to rate of change of magnetic flux linkage — A1

OR

loop cuts magnetic flux as it falls — (M1)

e.m.f. induced proportional to rate of cutting of magnetic flux — (A1)

(ii) magnetic flux into page through the loop decreasing — B1

induced current produces magnetic flux into page to oppose the decrease — B1

(right hand grip rule gives) induced current flowing clockwise in loop — B1

OR

magnetic flux density is higher in upper half then lower half of loop, so rate of flux cut and induced e.m.f. larger in upper half than lower half of loop — (B1)

direction of induced e.m.f. (drives induced current left to right) is same in both halves, so net e.m.f. — (B1)

drives current clockwise in loop — (B1)

(b) induced e.m.f.

$= -\frac{\Delta\Phi}{\Delta t} = -\frac{(30-120)\times10^{-3}\times\pi\times0.050^2}{0.040}$ — M1

$= 0.0177\text{ V} = 18\text{ mV}$ — A0

6 **(a)** period = 15 ms — C1

frequency = 1 / period = 1 / 0.015 = 67 Hz — A1

(b) r.m.s current
= 0.75 / √2 — C1

= 0.53 A — A1

(c) energy
$= I_{rms}^2 R t = 0.53^2 \times 450 \times 30 \times 10^{-3}$ — C1

= 3.8 J — A1

(d) instantaneous power P dissipated in resistor is $P = I^2 R$ where I is instantaneous current and R is resistance of resistor — B1

current sill flows in resistor in opposite directions during half-cycles, so heating resistor — B1

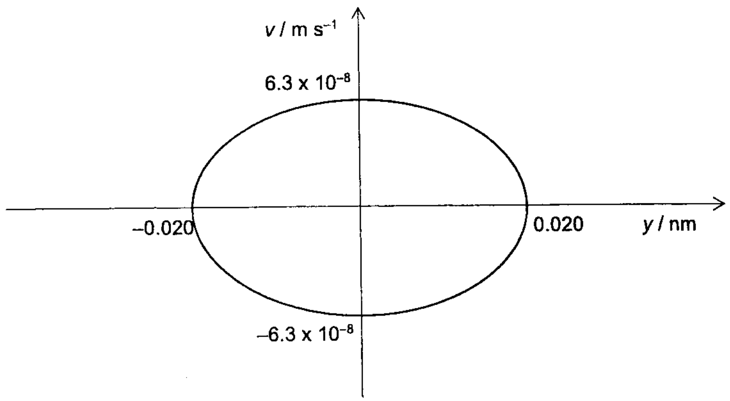
OR

average power $\langle P \rangle$ dissipated in resistor is $\langle P \rangle = I_{rms}^2 R$ where I_{rms} is root-mean-squared current and R is resistance of resistor — (B1)

I_{rms} not zero, so heating resistor — (B1)

Section B

7	(a)		progressive: energy transferred along direction of propagation of wave	B1
			longitudinal: particles along wave oscillate along axis parallel to direction of propagation of waves	B1
	(b)	(i)	amplitude = 2.0×10^{-11} m	A1
			frequency = 500 Hz	A1
		(ii)	maximum speed $= \omega x_0 = (2\pi \times 500) \times 2 \times 10^{-11}$	M1
			$= 6.3 \times 10^{-8}$ m s^{-1}	A0
		(iii)	maximum kinetic energy = ½ mv_0^2	
			$\frac{1}{2} \times m \times (6.3 \times 10^{-8})^2 = 2.4 \times 10^{-19}$	C1
			$m = 1.2 \times 10^{-4}$ kg	A1
		(iv)	ellipse / circle	M1
			with correct axes labels	A1



	(c)	(i)	energy transferred from beating wings to the ear / eardrum vibrates at same frequency as beating wing	B1
			frequency within audible range of person (20 Hz – 20kHz)	B1
		(ii)	intensity $\propto \frac{1}{\text{distance}^2}$	C1
			$\frac{1.6I}{I} = \left(\frac{2.0}{2.0-x}\right)^2$ where I is original intensity	C1
			$x = 0.42$ m	A1

[Turn over

(iii)	air molecule travels $4 \times 5.0 \times 10^{-9}$ (= 2.0×10^{-8} m) each cycle	C1
	total distance covered in 1800 beats = $1800 \times 2.0 \times 10^{-8} = 3.6 \times 10^{-5}$ m	A1
(iv)	device generate sound at same frequency as buzzing sound	B1
	of equal / similar amplitude	B1
	and 180° out-of-phase / anti-phase	B1
	leads to destructive interference of buzzing sound and the generated sound	B1
	that cancels the buzzing sound	

8 (a) (i) 1. mass — B1

2. positive electric charge — B1

(ii) magnetic force acts on moving charge in magnetic field, force on it may not be due to electric field — B1

(b) (i) magnitude of magnetic flux density at wire *X*
$= \frac{\mu_0 I}{2\pi d} = \frac{4\pi \times 10^{-7} \times 290}{2\pi \times 0.050}$ — M1

$= 1.2 \times 10^{-3}$ T — A0

(ii) $F = BIL \Rightarrow \frac{F}{L} = BI$

force per unit length
$= 1.2 \times 10^{-3} \times 290$ — C1

$= 0.35$ N m^{-1} — A1

(c) (i) electron moving perpendicular in magnetic field experience a magnetic force — B1

force
$= Bqv = 4.64 \times 10^{-3} \times 1.6 \times 10^{-19} \times 2.9 \times 10^{7}$ — M1

$= 2.15 \times 10^{-14} = 2.2 \times 10^{-14}$ N — A0

(ii) magnetic field between the wires is not uniform — B1

magnetic force / resultant force on electron not constant — M1

so, claim is incorrect — A0

(iii) curve downwards — B1

(d) [Method 1]
electric force on electron $= qE = 1.6 \times 10^{-19} \times \frac{13500}{0.10} = 2.16 \times 10^{-14}$ N — M1

either force equal to **(c)(i)**, so constant velocity
or force ≠ **(c)(i)**, so cannot be constant velocity — A1

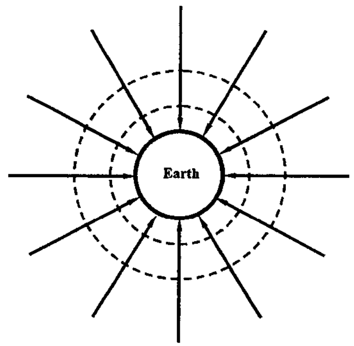
[Method 2]
For electron to move at constant velocity, magnetic force = electric force
$Bev = eE \Rightarrow v = \frac{13500}{0.10} / 4.64 \times 10^{-3} = 2.91 \times 10^{7}$ m s^{-1} — M1

either given speed = speed required, so constant velocity
or given speed < speed required, so cannot be constant velocity — A1

(e) minimum **four** field lines directed towards Earth radially — B1

minimum **two** concentric circles for equipotential surface — B1

minimum **three** circles with increasing distance between one circle and next outer circle — B1



(f) (i) gravitational field strength by earth = gravitational field strength by moon
$\frac{GM_{Earth}}{x^2} = \frac{GM_{moon}}{(3.84 \times 10^{8} - x)^2}$ — C1

$\frac{5.98 \times 10^{24}}{x^2} = \frac{7.35 \times 10^{22}}{(3.84 \times 10^{8} - x)^2}$ — C1

$x = 3.5 \times 10^{8}$ m — A0

(ii) *either* acceleration (or resultant force) of spaceship and its displacement from P is in the same direction
or spaceship accelerates towards Earth if displaced left of P or towards moon if displaced right of P — M1

so claim incorrect — A1

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Question	Answer	Marks
1(a)(ii)	Value of raw V with unit in the range 1.0–1.6 V and to nearest 0.01 V.	1
1(b)(iii)	Values of p and q with consistent unit, $q > p$, both values < 1 m and $p + q = 1$ m	1
1(c)	Six sets of readings of R (different values), p and q, including **(b)(iii)**, with correct trend (as R increases, q decreases) and without help from Supervisor	1
	Column headings: Each column heading must contain a quantity and a unit where appropriate. The presentation of quantity and unit conform to accepted scientific convention e.g. q / cm, q / R (cm Ω^{-1}). No unit given for q / p.	1
	Consistency: All values of p and q must be given to the nearest mm.	1
	Significant figures: All calculated values (q / R and q / p) must be given to the least number of significant figures as the raw values.	1
	Calculation: Values of q / p are correct.	1
1(d)(i)	Axes: Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions). Scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions. Scales must be labelled with the quantity that is being plotted. Scale markings should be no more than two large squares apart.	1
	Plotting of points: All observations must be plotted on the grid. Diameter of plotted points must be ≤ half a small square (no "blobs"). Points must be plotted to an accuracy of half a small square.	1
	Line of best fit: Judge by balance of all points on the grid about the candidate's line (at least 5 points). There must be an even distribution of points either side of the line along the full length. Allow one anomalous point only if clearly indicated (i.e. circled or labelled) by the candidate. There must be at least five points left after the anomalous point is disregarded. Lines must not be kinked or thicker than half a small square.	1

Question	Answer	Marks
1(d)(ii)	Gradient: Gradient sign on answer line matches graph drawn. The hypotenuse of the triangle used must be greater than half the length of the drawn line. Method of calculation must be correct. Both read-offs must be accurate to half a small square in both the x and y directions.	1
1(e)	Zero error (both present and absence) indicated, evidence of repeated measurement of diameter and obtain the average.	1
	Diameter is recorded to the nearest 0.01 mm.	1
	Correct calculation of ρ using the answer in **(d)(ii)** and conversion of diameter to m.	1

Question	Answer	Marks
2(a)	Final value of s_A to at least two significant figures <u>and</u> in the range 1.0–1.1 mm.	1
	Evidence that s_A has been correctly calculated from a measurement of at least $10s_A$.	1
2(b)	Value of F in the range 50–70°.	1
2(c)(i)	Values of sin F and sin $(F - G)$ calculated correctly.	1
2(c)(ii)	All points plotted to an accuracy of half a small square.	1
2(c)(iii)	When lines on grids A and B are parallel	1
	$F = G = 0°$	1

Question	Answer	Marks
3(b)(iii)	• All raw readings of timing stated to 0.01 s. • Value for T given to the correct number of significant figures as timings with unit. • T in the range 0.50 s to 0.90 s.	1
	Evidence that of repeats (at least two recordings of $nT \geq 15$ s).	1
3(c)(i)	Correct calculation of l.	1
3(c)(ii)	Justification of s.f. in l linked to s.f. in raw time (or period) and g.	1
3(d)(ii)	Value of $d = l \pm 0.050$ m.	1
3(d)(iii)	Absolute uncertainty in d in range 2 mm–8 mm (if repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown). Correct method of calculation to obtain percentage uncertainty expressed to 1 or 2 s.f.	1
3(e)(ii)	Value for t in the range 2.0 s–8.0 s.	1
3(f)	Second value of d > first value of d.	1
	Second value of t > first value of t.	1
3(g)(i)	Two values of α calculated correctly to at least 2 significant figures with unit $kg^{0.5}$ s.	1
3(g)(ii)	Valid comment by comparing the percentage difference of the values of α and percentage uncertainties in d.	1
3(h)(i)	Establish initial extension or length of spring with mass hangar or some initial mass (with ruler)	1
	Increase load by adding (slotted) mass, measure new length and determine extension.	1
	Plot load against extension and obtain k from the gradient or calculate k = load / extension for each set of data and average. (This mark is awarded only if there is evidence of at least 2 sets of data obtained.)	1
3(h)(ii)	At least two different masses used for each spring.	1
	Clear presentation of the mass added, extension and k. e.g. the use of table or values are listed properly.	1
	k for silver spring 20 N m^{-1} to 25 N m^{-1} and k for black spring 15 N m^{-1} to 20 N m^{-1}	1
3(h)(iii)	Express the unit of the LHS and RHS of equation in terms of SI base unit (unit of $k^p = kg^p\ s^{-2p}$, unit of $\sqrt{m} = kg^{0.5}$, unit of t = s)	1
	$p = -0.5$.	1

Question	Answer	Marks
3(h)(iv)	At least one set of measurements with the black spring (*m*, *T*, *l* or *d* and *t*).	1
	Compare value of *t* for the black spring with the silver spring for the <u>same *m*</u>.	1
	Valid comment based on the values of *t*.	1

Question	Answer		Marks
4	**Diagram**		
	labelled diagram of workable experiment including method to support the pipe vertically e.g. retort stand with clamps		1
	Methods of data collection		
	M1	Method to measure *B* e.g. magnetic field sensors with datalogger, hall probe.	1
	M2	Method to measure *d* e.g. use inside measuring jaws of vernier calipers, travelling microscope.	1
	M3	Method to measure *v* • light gate(s) or motion sensor attached to datalogger. • equipment to measure the velocity shown correctly on the diagram e.g. motion sensor a distance away from bottom of pipe pointing upwards towards pipe or light gates in the path of the magnet exiting the pipe.	1
	M4	Method to ensure that copper pipe is vertical, e.g. spirit level, plumb line.	1
	Controlling variables		
	C1	Use the <u>same magnet</u> when varying *d*.	1
	C2	Use the <u>same pipe</u> when varying *B* with <u>different magnets</u>.	1
	Method of analysis		
	A1	Plot a graph of lg *v* against lg *B* to obtain a <u>straight line</u> with gradient = *m*.	1
	A2	Plot a graph of lg *v* against lg *d* to obtain a <u>straight line</u> with gradient = *n*.	1
	Additional details including safety consideration		**Max. 3**
	D1	Safety precaution linked to falling magnets/use sand tray/cushion to soften fall.	
	D2	Adjust magnetic field sensor / Hall probe until maximum reading obtained/perpendicular to field/pole.	
	D3	*either* take readings for *B* at both poles and <u>average</u> *or* measure *d* at both ends / different directions and <u>average</u>.	
	D4	*either* repeat experiment with magnets reversed and <u>average</u> *or* repeat *v* for same *B* and *d* and <u>average</u>.	
	D5	Reasonable method(s) to release magnet at constant position / from rest / centre of pipe.	
	D6	Conduct experiment away from other sources of ferromagnetic material/ external magnetic field.	

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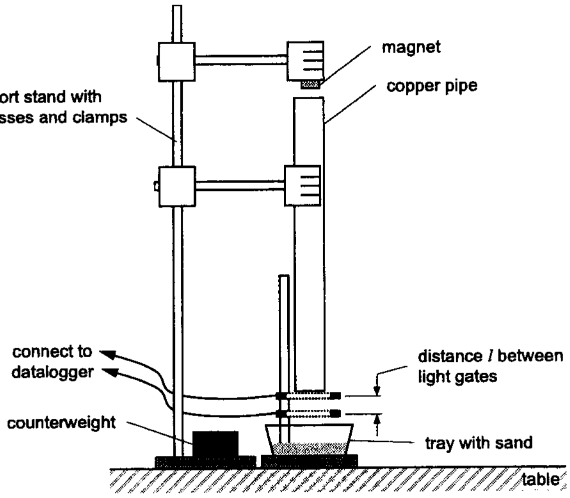
Preparing the apparatus



1. (a) Measure the magnetic flux density B of ten different magnets using a magnetic field sensor connected to the datalogger. When taking readings, adjust magnetic field sensor until maximum reading is obtained. Readings are taken at both poles and averaged.

   (b) Measure the internal diameter d of ten different copper pipes using the inside measuring jaws of vernier calipers. Measurements should be taken at both of the pipe and averaged.

2. (a) Set up the apparatus as shown in the diagram. Select retort stand and clamps that are non-ferromagnetic. Ensure that any ferromagnetic material are sufficiently far from the setup.

   (b) Place a tray with loosely packed sand to soften the fall.

   (c) The copper pipe is clamped and use a spirit level to ensure it is vertical.

   (d) The light gates are set up just below the bottom end of the pipe separated by a short distance l measured with a meter rule.

   (e) The magnet is held by a second pair of clamps above the pipe. During the experiment, the clamp is loosen to allow the magnet to drop through the centre of the pipe from the same position.

Experiment 1: Vary magnetic flux density *B*

3. Use the pipe with the smallest value of d and clamp the magnet with the lowest value of B.

4. Start the datalogger to collect the data. Release the clamp so that the magnet drops through the pipe.

5. Record the time t taken for the magnet to fall between the two light gates from the datalogger. The terminal velocity $v = l / t$.

6. Repeat step 4 and 5 to obtain another value of v and determine the average v.

7. Repeat step 4 to 6 with the remaining nine magnets using the same pipe throughout the experiment.

8. Plot a graph of lg v against lg B to obtain a straight line. The gradient of the straight-line graph will give the value of m.

Experiment 2: Vary internal diameter of the pipe *d*

9. Use the pipe with the smallest value of d and clamp the magnet with the lowest value of B.

10. Start the datalogger to collect the data. Release the clamp so that the magnet drops through the pipe.

11. Record the time t taken for the magnet to fall between the two light gates from the datalogger. The terminal velocity $v = l / t$.

12. Repeat step 10 and 11 to obtain another value of v and determine the average v.

13. Repeat step 10 to 12 with the remaining nine pipes using the same magnet throughout the experiment.

14. Plot a graph of lg v against lg d to obtain a straight line. The gradient of the straight-line graph will give the value of n.