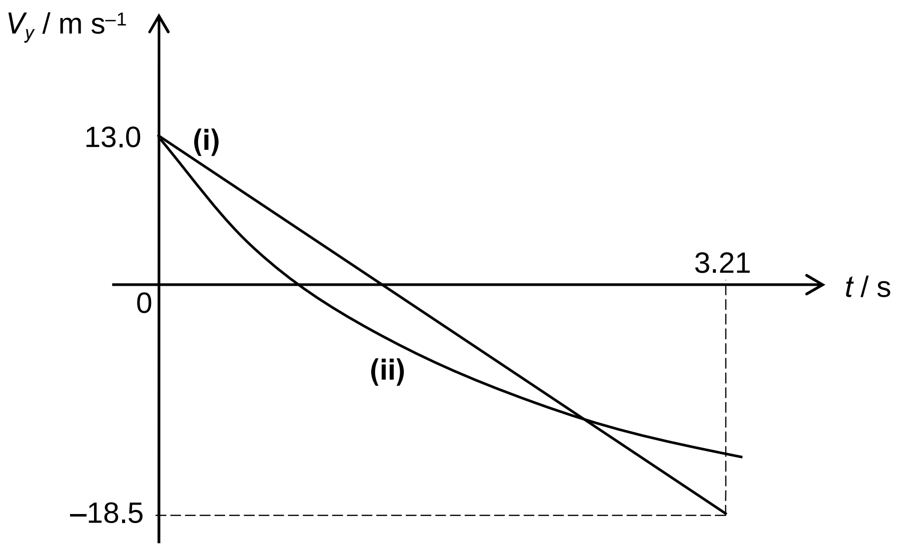
National Junior College 2022 Preliminary Examination

9749 H2 Physics

Paper 2

1	**(a)**	**(i)**	$-8.75 = (15.0 \sin 60^o)\, t + \tfrac{1}{2}(-9.81)\, t^2$ $8.75 = (-15.0 \sin 60^o)\, t + \tfrac{1}{2}(9.81)\, t^2$	M1 (M1)
			solving t = 3.21 s	A0
		(ii)	range of projectile = $(15.0 \cos 60^o)(3.21)$ = 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

$v = 0.35\ \text{m s}^{-1}$ 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

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

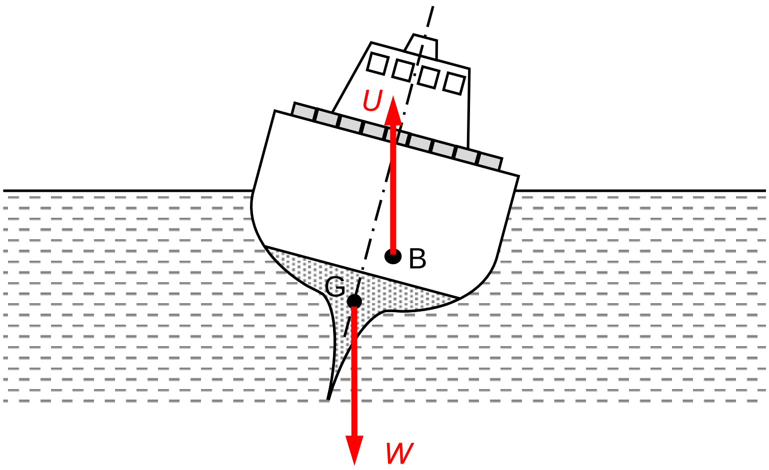
appears / seems to act A1

(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 = $2.14 \times 10^5\ m^3$ 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

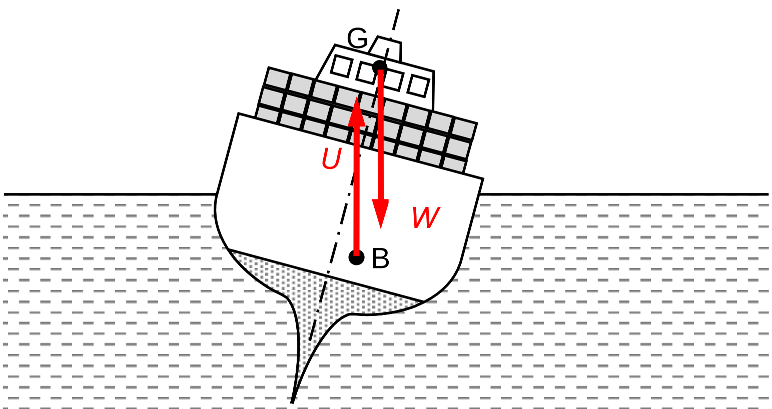


(ii) weight (or *W*) and upthrust (or *U*) forms a couple M1

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

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* $R_P=\frac{6}{6\times10^{-3}}$ $(=1000\ \Omega)$ C1

$R_Q=\frac{6}{3\times10^{-3}}$ $(=2000\ \Omega)$ 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 $\frac{mv^2}{r} = Bqv \Rightarrow mv = Bqr \Rightarrow \text{momentum} \propto \text{radius}$	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

$\frac{N_t}{N_{12}} = \frac{N_0}{N_{12}} \exp\left(-\frac{\ln 2}{t_{1/2}} t\right)$

$\frac{1}{8.6 \times 10^{10}} = \frac{1}{3.3 \times 10^{10}} \exp\left(-\frac{\ln 2}{5700} t\right)$ 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

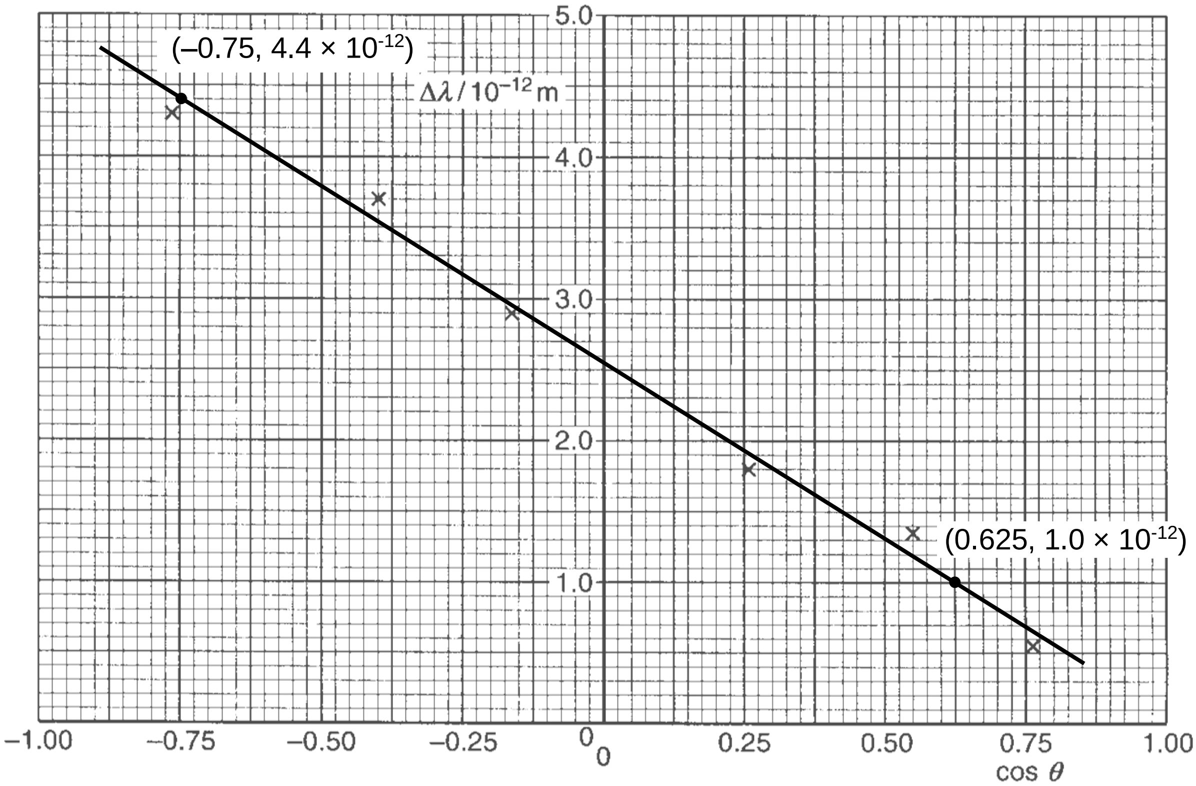
$\cos\theta = 0.26 \pm 0.08$ (or ± 0.09) A1

(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 $\Delta\lambda$ 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

$k = -\text{gradient}$ <u>and</u> with unit m A1

OR

$k = \text{y-intercept}$ <u>and</u> with unit m (M1)

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

OR

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

k calculated correctly <u>and</u> with unit m (A1)

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

(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