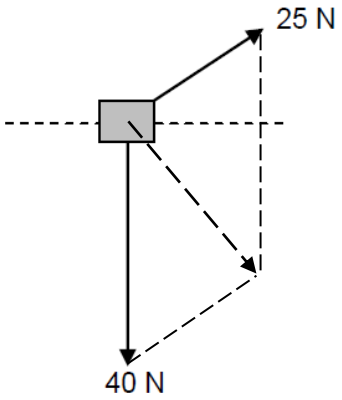
2024 4 IP EOY
SUGGESTED ANSWER SCHEME

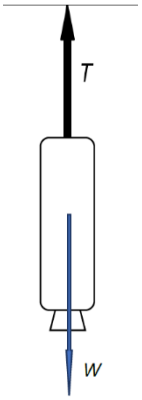
PAPER 1 (40 marks)

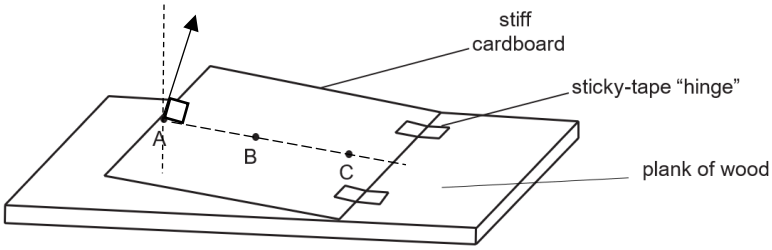
Qn	Answer	Explanation
1	**C**	Acceleration and Weight are vectors while the rest are scalars.
2	**D**	T: Density = 10/ 8.0 = 1.25 g/cm^3 U: Density = 10/ 12.0 = 0.83 g/cm^3 V: Density = 20/ 16.0 = 1.25 g/cm^3 W: Density = 20/ 8.0 = 2.5 g/cm^3
3	**B**	By completing the parallelogram, resultant will be the diagonal. 
4	**A**	As the ball drops vertically it undergoes constant acceleration due to free fall, hence the first part of the graph must be a straight line of constant gradient. When the ball hits the ground and rebounds in the opposite direction, its velocity drops to zero and as it rebounds in the opposite direction, the graph shows a drop to zero velocity and then a negative velocity. Subsequently, it goes upwards with a constant gradient.
5	**B**	$v / t = a$ v / 2.0 s = 10 m/s^2 v = 20 m/s area under velocity – time graph gives you displacement hence h = ½ x 20 x 2.0 = 20 m
6	**D**	$a = (v – u)/t$ 2.0 m/s^2 = (v - 5.0 m/s)/ 10s v = 25 m/s
7	**B**	$Fnet = ma$ 2N – 1N = 10a a = 0.1 m/s^2
8	**C**	Action and reaction pair act at the same time, on mutually different bodies, have the same magnitude but opposite directions.
9	**C**	Since there is no air resistance, both divers will fall with the *same acceleration* due to gravity and hence will have the *same velocity* before they the water. *Distance travelled* is obviously the same as they both jump from the same height. As energy in kinetic store = ½ x m x v^2; since their mass are different, their energy in kinetic store will be different.
10	**A**	Rate of work done against air resistance = Force x Distance / time = 3.0 N x (1/2 x 5.0 m/s x 10s) /10s = 7.5 W

11	**B**	$P = mgh/t$. Larger mass of ball lifted to a greater height will require greater power when time taken to pick the ball is the same for all four.
12	**D**	Steam from the boiler turns the turbines.
13	**C**	Applying principle of moments, 6.0 N x 10 cm + 4.0 N x 30 cm = 5.0 N x d $\Rightarrow$ d = 36 cm The 5.0 N weight is acting at the 86 cm mark
14	**B**	Bar 2 , Take moments about any one of two edges will result in either a clockwise or anticlockwise moment.
15	**A**	Height change of P and Q = 20 m ; Height change of R and S = 40 m
16	**D**	Since the mercury level in both arms are at the same level, pressure exerted by liquid X column = Pressure exerted by liquid Y column. From $h_X\rho_X = h_Y\rho_Y$, $h_X > h_Y \Rightarrow \rho_Y > p_X$
17	**B**	Height of the barometer is independent of the cross-sectional area.
18	**A**	Molecules cannot expand (statement 1 incrorrect). They cannot move further apart as the volume if fixed (statement 4 incorrect).
19	**C**	A is radiation; B is conduction ; C is radiation and conduction
20	**D**	Pressure of gas X > P_{atm} to cause the piston to move. After opening its pressure will reduce to the same as P_{atm} but not lesser for that will shift the piston inwards. Nor will the pressure be more as that will indicate that the piston will continue moving whilst it is already mentioned that it just moves slightly to the right.
21	**C**	A is incorrect as the liquid is not boiling yet. B is incorrect evaporation only applies to molecules at the liquid's surface but not ANY molecules. D is incorrect because it describes boiling.
22	**D**	Liquid Y expands and contracts more per degree change.
23	**C**	Z being a positively charged rod, will attract free mobile electrons to the right side of Y, inducing positive charges on the left side of X. When earthed, electrons will flow up to neutralise the positive charges on the left side of X. Hence X will be neutral and Y will be negatively charged.
24	**C**	Electric forces are action and reaction forces. They will be of the same magnitude but opposite in direction. Hence $F_1 = F_2$ and $x = y$.
25	**A**	When the switch is closed, current will take the upper loop path and by pass the lower path. Hence $A_1 = A_2$.
26	**A**	Current that flows out of the cell will pass through R_1 before splitting up to the branches of R_2 and R_3, R_4 & R_5. Since V = IR, R_1 will have the biggest potential difference.
27	**D**	When bulb 1 breaks, the overall resistance increases and hence current will decrease. Voltage across bulb 2 will be larger and the voltage across bulb 3 and 4 will be smaller. Hence, bulb 2 becomes brighter and bulb 3 and 4 becomes dimmer.
28	**C**	$P = VI$ 1500 W = 240 V x I I = 6.25 A Current flowing in the live wire must be the same as that in the neutral wire. Earth wire carries no current when the kettle is working normally.
29	**A**	From $R = \rho l/A$, the longest wire with the smallest diameter (and hence the smallest cross-sectional area) will have the greatest resistance.
30	**B**	There is an attraction by BOTH the S and N poles of the two magnets$\Rightarrow$ X is a soft iron. A stronger magnet will induce and attract the soft iron more, thereby producing a smaller resultant downward force (Weight – magnetic force = resultant downward force)
31	**A**	Appling right hand grip rule, compass Q is pointing to the left. Compasses P and R is pointing due North as the magnetic field at the plane of the paper is perpendicular to the compass and does not affect it, thus both N-pole of the two compasses points due North
32	**A**	When the magnet enters the coil, there will be a changing magnetic flux linkage with the conductor and an emf will be induced. When the magnet is halfway through the coil, the emf induced on both ends of the coil will cancel out each other; hence there will be no induced emf. When the magnet leaves the coil, the induced emf will be opposite to the initial emf due to Lenz's law.
33	**B**	Secondary voltage = 50 V x (100/10) = 5.0 V $V = IR$ 5.0 V = I x 25 I = 0.20 A

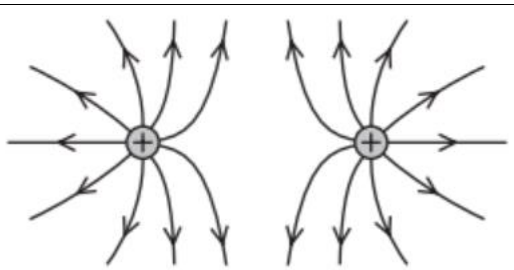
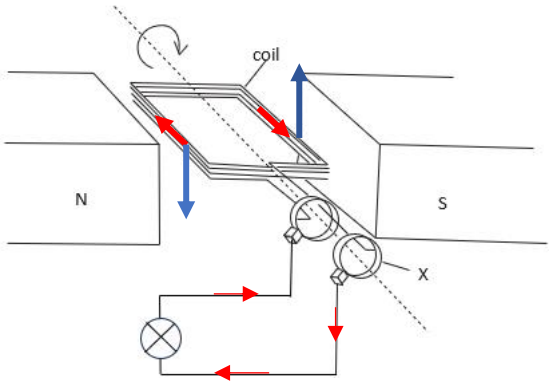
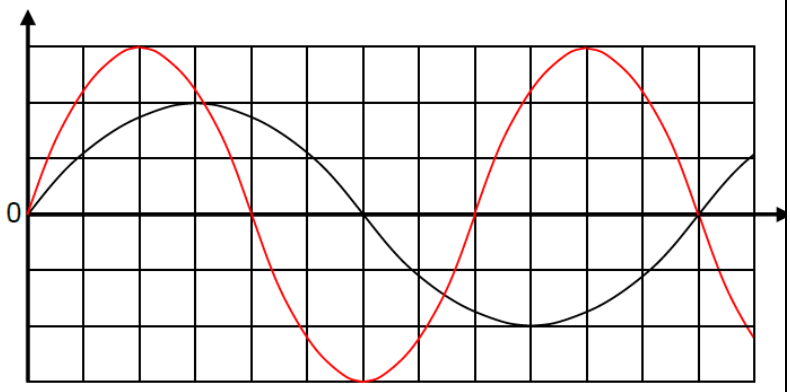
34	**B**	The next ¼ cycle will see Q at the equilibrium position and is continuing to move down while P is at the crest and is also on the verge of moving down.
35	**D**	All EM waves travel at the same speed in vacuum. X rays have a higher frequency and hence a shorter wavelength compared to visible light
36	**B**	Y amplitude is twice that of X. X executes 2 cycles within the same time as Y. Thus $f_x = 2\,f_y$
37	**C**	The wavelength of UV radiation (UVR) lies in the range of 100–400 nm; X-rays have a wavelength in the range of 0.01–10 nm ; Visible light's wavelengths in the range of 400–700 nm; Infrared (IR) radiation's wavelengths between 760 nm and 100,000 nm
38	**B**	There is no β-radiation as the count rate did not drop to below 25000 counts/min when aluminium is used.
39	**D**	Ionising radiation can mutate cells.
40	**B**	38000 → 17000 (2 years) ; 26000 →12000 (2 years)

PAPER 2 SECTION A (70 marks)

Qn	Part	Answer	Remark
1	(a)	The ping pong ball is momentarily at rest at the maximum height, hence there is no air resistance acting on it. The only force acting on the ball is weight as such it experiences acceleration due to gravity only which is 10 m/s^2 since g = W/m.	
	(b)	The ball rises up with a decreasing deceleration from 0 to 0.2 s [1] The ball then falls with a decreasing acceleration from 0.2 s to 2.2s where it reaches terminal velocity. [1]	
	(c)	displacement =(½ (2 + 8) x 3) m = 15 m [2] Average velocity = 15 m /3 s = 5.0 m/s [1]	
2	(a)	$a=(v-u)/t$ = (82-10) ms^{-1}/8.0 s = 9.0 m/s^2 [1] $W=m\,x\,g$ =1.8 x 10^6 kg x 9.0 N/kg [1] =1.6 x 10^7 N	
	(b) (i)	 *T* drawn to be longer than *W*. [1] *W* should be drawn from the CG of object. *T* should be upwards. [1]	

	(b) (ii) 1 & 2	$F_{net} = T - W$ $= ma$ $T - (1.6 \times 10^7 N) = 1.8 \times 10^6$ kg x 4.1 N/kg $T = 23.58 \times 10^6$ N $= 2.4 \times 10^7$ N [1]	ecf allowed from (a) for *W*
	(b) (iii)	As the shuttle lands, its mass/weight decreases due to the burning of fuel, hence the upright resultant force is increasing (as thrust is constant) and deceleration is increasing	
3	(a)	Gain in GPE = *mgh* = 800 kg x 10 Nkg^{-1} x 8.0 m [1] = 64 000 J [1]	
	(b)	80% = (output / input) x 100 % Input energy by motor = (64 000 + 16000 /80) x 100 = 100 000 J [1]	
	(c)	Power = WD / time = 100 000 / (16/0.40) W [1] = 2000 W [1]	
4	4(a) (i)	Line of force drawn at A, shown to be perpendicular to the cardboard at A. Indicate right angle between line of action of force and cardboard. Angle = 90° 	Collective mark – drawing must be correct in addition to the 90° angle
	(ii)	▪ A is the furthest from the axis of rotation/hinge of the cardboard, thus the perpendicular distance to the hinge is the largest. ▪ From Moment = *F* x perpendicular distance, the largest distance will need a smallest force to produce the same moment.	
	(b)	▪ Diagram drawn with CG directly above the edge of matchbox when about to topple ▪ The line of action of the weight is at the edge of the matchbox when the about to topple. When the line of action falls outside the edge, a net moment results and toppling occurs.	
	(c)	Angle is smaller than the angle before the box of matches falls in Fig. 4.2 Explanation : the CG is raised when the matchbox is opened. The line of action of the weight will reach the edge of the matchbox earlier.	less stable with higher CG must have mention of weight reaching edge earlier
5	(a) (i)	Force = Pressure x Area = 3.8 cx 10^5 Pa x 6.1 x 10^{-4} m^2 = 2.318 x 10^2 N = 2.3 x 10^2 N (2 s.f.)	
	(ii)	Atmospheric pressure is also acting on the piston from the left. This will reduce the force needed to be applied by the student.	

	(b)	▪ Volume ↓ , number of molecules per unit volume ↑ ▪ Frequency of collision ↑ (Average) force per unit area (pressure)↑	Penalise increase speed
6	(a) (i)	▪ Thermal energy is conducted from the heater to the surrounding water molecules above X via **molecular vibration**. ▪ Water molecules near the heater **move faster and collide into others surrounding water molecules, thus increasing their kinetic energy/store.** ▪ Water molecules also **move further apart** as they gain kinetic energy The moving apart of the water molecules decreases the density of water. The less dense heated water rises up the tank, resulting in the water above X to quickly rise in temperature.	
	(ii)	▪ Due to the **larger body of water below X**, the thermal energy from X is distributed to **more water particles** via **molecular vibration**. ▪ As transfer of thermal energy via molecular vibration is a slow process, the larger number of water molecules below X will cause the temperature to rise more slowly compared to those above X.	
	(b)	▪ Plastic has no free electrons hence the transfer of thermal energy from the heated water is via vibration of particles 0nly. The transfer process is very slow through the plastic. ▪ Collisions between air particles is very low probability due to the large spaces between them and their random movement. Transfer of kinetic energy from molecule to molecule via collisions is thus very remote and slow.	Reject air is a good insulator/poor conductor without molecular explanation.
7	(a)	When the switch is closed, current will flow through the coil and the iron core becomes an electromagnet. [1] The iron bolt will become an induced magnet and the electromagnet attracts the iron bolt, causing it to move to the left, allowing the door to be opened. [1]	
	(b) (i)	▪ Increase the current/ e.m.f./ supply ▪ increase the number of turns on the coil ▪ move the iron core closer to the iron bolt.	
	(ii)	▪ increase the current/emf / number of turns increases the strength of the magnetic field and thus increases the force of attraction on the iron bolt ▪ Magnetic field is stronger when magnet is closer to the poles of the electromagnet	
	(c)	The door may not open as the magnetic field generated by the solenoid are not concentrated by the iron core to produce a stronger magnetic field in order to induce and attract the iron bolt.	
8	(a) (i)	Due to charging by friction, [1] electrons are transferred/removed from the pads and deposited on to the paper [1], Since the paper has excess electrons, it is negatively charged	
	(ii)	The glue droplets are charged oppositely to the paper (positively) and unlike charges attract hence the droplets are attracted paper easily. [1] The droplets also repel each other, as like charges repel hence it spread out and stick to the paper evenly. [1]	

	(c)		
9	(a)	▪ The induced current in the coil is an alternating current. ▪ When the current reaches its maximum, the bulb **increases** in brightness. ▪ When the current drops to zero, the bulb's brightness **decreases.** ▪ This periodic increase and decrease in brightness makes the bulb blinks.	
	(b)	▪ To provide good contact between the coil and the carbon brushes/external circuit ▪ To allow freedom of rotation of the coil (without twisting the wires of the coil)	
	(c)		Correct current direction must be drawn in BOTH external circuit and the coil. Incomplete current drawn in either the coil and/or the external circuit will have no marks awarded.
	(d)	current  *frequency increases by 3/2 = 1.5 times* *period decreases by 1.5 times* (12/1.5) from 12 to 8 squares [1] *amplitude increases by 1.5 times:* from 2 to 3 squares [1]	
10	(a)	The direction of vibration of the particles (of the medium) is parallel to the direction of propagation of the (sound) waves.	
	(b)	From $\lambda = v/f$	

	(i)	= 1500 ms^{-1} / 42000 Hz = 0.036 m	
	(ii)	▪ Energy in the ultrasound is transmitted/carried through the cleaning liquid by liquid particles whose oscillations cause compressions and rarefactions. ▪ The energy is then transferred to the jewellery, causing the atoms of the jewellery to also undergo oscillations at the same frequency of the ultrasound. ▪ The vibration of the atoms is transmitted to and loosen any attachment deposited on the jewellery, thus cleaning it in the process.	
11	(a)(i)	T & Q ; U & R	Any one pair
	(ii)	They differ in the number of neutrons.	
	(b) (i)	Random in space – unable to predict the direction which the radiation emerges Random in time - unable to predict when the radioactive nucleus will decay.	Collective mark
	(ii)	$^{222}_{86}Rn \rightarrow {}^{218}_{84}Po + {}^{4}_{2}\alpha$	
	(c) (i)	Electron / β – particle	
	(ii)	The number of protons increase by one **<u>and</u>** the number of neutrons decrease by one / A neutron decays to a proton and a β – particle* *($^{1}_{0}n \rightarrow {}^{1}_{1}p + {}^{0}_{-1}\beta$)	

SECTION B(10 m)

12	**EITHER**		
	(a)	The difference is in the work done in driving a unit charge through the entire circuit and through a component.	
	(b) (i)	2.0 V across 0.9 MΩ 4.0 V across the voltmeter will be twice the resistance according to potential divider principle, total resistance across points X and Y = 0.9 × 2 = 1.8 MΩ [1] OR $R_{total} = \frac{4.0\ V}{(\frac{2.0\ V}{0.9M\Omega})}$ = 1.8 MΩ	
	(b) (ii)	Resistance across the thermistor, *R* 1/ 1.8 MΩ= 1/ *R* + 1/ 5.2 MΩ [1] *R* = 2.75 MΩ [1] From Fig. 12.1, the temperature of the thermistor = 22.0 °C [1]	
	(c)	▪ $R_{\text{therm}} \uparrow\ \theta \downarrow$ $R_{\text{parallel}} = \frac{R_{therm}5.2M\Omega}{R_{therm}+5.2M\Omega}$; Since $R_{therm}5.2M\Omega > R_{therm} + 5.2M\Omega \Rightarrow R_{\text{parallel}}$ increases. Thus voltmeter reading will increase using the potential divider equation.	Alternative explanation acceptable if explanation is conceptually correct.

	(d)	$P = V^2 / R$ $R = 230^2 / 50$ [1] $= 1060\ \Omega$ (3 s.f.) [1]	
		Energy used in a year = 0.050 kW × 3.6 h × 365 = 65.7 kWh [1] Cost in a year = 65.7 × 0.29 × 3 = \$57.2 [1]	
12	OR		
	(a)	The fixed temperature when a liquid changes into a gas / substance changes from the liquid state to the gaseous state	
	(b)	▪ Energy supplied to break the bonds between molecules and the kinetic energy for the molecules to move in the liquid state ▪ Energy needed to overcome the forces of attraction between the escaping molecules and the bulk of liquid. ▪ Provide the kinetic energy for the water molecules to escape from the water surface ▪ For the molecules to do work against the atmospheric pressure	Any two mentioned
	(c) (i)	$P = VI$ = 6.0 V x 2.0 A = 12 W [1]	Collective mark awarded for correct answer and unit
	(ii)	Thermal energy = 12 W x 60 s = 720 J [1]	
	(iii)	From $Q = ml$ 720 J = m x 9.0 x 10^5 J/kg m = 8.0 x 10^{-4} kg or 0.80 g	
	(d) (i)	The weight of the piston and the force acting on the piston due to atmospheric pressure is acting vertically downwards. Let this be $W+P_{atm}(A)$ where A is the piston's cross-sectional area. To maintain a constant upward speed of the piston, the resultant force = 0 N. Thus, upward force on the piston by the air particles, $U = W+P_{atm}(A)$ This upward force did not change throughout the motion of the piston as $W+P_{atm}(A)$ is a constant	
	(ii)	1. The number of molecules per unit volume remains constant on the average as the piston moves up (increase in number of particles is compensated by the increase in volume) 2. The increase in the force of impact of the particles due to higher velocity/temperature is equalled by the drop in the frequency of collisions with the increase in volume as piston's wall as it moves up. The upward force U is thus constant.	Both factors mentioned