2024 PRELIM PHYSICS
SUGGESTED ANSWER SCHEME

PAPER 1 (40 marks)

Qn	Answer	Explanation
1	**B**	The clay will displace the same volume when it is placed in the bigger cylinder.
2	**C**	Mass is unchanged, thus A & D is incorrect. Weight at both points are different as the acceleration of free fall is different, thus B is incorrect.
3	**C**	By Pythagoras theorem, only C and D is possible. To construct a right-angle triangle at the point where the two cords meet, F_2 has to be the larger force (8 N).
4	**B**	Since the routes have different distances, average speeds for both are different. Displacement is the same from P to R even though distances are not equal.
5	**A**	Calculating the area above the time axis: On Earth, height = ½ (1.2)(12)m=7.2 m ; On Mars, height= ½ (3.2)(12) m = 19.2 m Thus height difference = 12 m
6	**B**	Total displacement = (+3.0 x 10)m + (-6.0 x 5)m = 0.0 m Average velocity = 0.0 m /15s = 0.0 ms^{-1}
7	**B**	A, B and C all demonstrates forces acting on the SAME body.
8	**A**	Gravitational potential store = $mgh \Rightarrow h$ = Gravitational potential store / mg. Thus $h \propto 1/m$
9	**C**	A and B are incorrect as there is no net work done since the suitcase is stationary. On the slide, work is not done on the suitcase – the suitcase slides down due to its own weight. C – work is done on it to raise it up by 10 m.
10	**C**	Rate of increase in the kinetic store = (500 – 200)x 10^3 N x 40 ms^{-1} = 12 x 10^6 W
11	**C**	Taking moments about the pivot, 0.43 N x (6 -2.4) cm = W x 1.2 cm W = 1.3 N
12	**C**	Centre of gravity has to be at the pivot for the object to be at neutral equilibrium.
13	**B**	Pressure of the gas = pressure due to piston + Atmospheric pressure 1.2 x 10^5 Pa = (4.0 x 10)/A + 1.0 x 10^5 Pa A = 2.0 x 10^{-3} m^2
14	**A**	Adding mercury to the trough will not affect the height h which is a measure of the atmospheric pressure.
15	**C**	Since temperature remains constant, the average speed of the gas molecules remain constant. However, when compressed the density of the gas increases and hence the frequency of collisions of the gas molecules with the walls of the container increases.
16	**B**	When air is sucked out, the pressure inside the packet drink decreased as the number of air molecules per unit volume in the packet decreased due to the decrease in the frequency of collision of the air molecules on the packet wall.
17	**A**	B is incorrect as heat transfer is unidirectional and there is no such concepts as coldness. C's description is heat transfer is via convection and not radiation. At thermal equilibrium there is no NET flow of thermal energy but thermal energy exchange is continuous.
18	**B**	When water changes state from liquid to solid, the particles have to come closer together by losing internal energy and hence their average potential energy decreases due to the closer average distance between the molecules.
19	**C**	Thermal energy supplied to X = Thermal energy supplied to Y (Cx) θ = (Cy) 2θ Cx = 2 Cy
20	**A**	Thermal energy lost by water = Thermal energy gained by ice 0.500 x 4200 x (30 - θ) = (80 x 334) + (0.080 x 4200 x θ) θ = 14.9°C
21	**B**	P has the same brightness as Q but dimmer than R since the potential across both is lower than that across R. When filament in Q breaks, the potential difference across P is the same as R. The potential across P rises and the potential across R lowers. So P becomes brighter while R dims.
22	**B**	Current passing through the 24.0Ω and 6.0Ω resistors = 15.0 V/30.0Ω = 0.5 A. Thus the current passing through the other arm = 1.0 Ω. $V_{24} = 0.5(24)V = 12\ V$; $V_6 = 1(6)V$= 6.0 V. The voltmeter thus registers a difference of 6.0 V.

23	**C**	Total kWh (unit) consumed = 0.1 kW x 21 x 5 hr = 10.5 kWh. Total cost = 10.5 kWh x $0.24 /kWh = $2.52
24	**C**	Fuse prevents excessive current from passing through , thus preventing excessive joule heating due to I^2R.
25	**A**	Since all are metals and, when in contact, they all become a single conductor. The positive charges will be 'distributed' with the movement of the electrons throughout the spheres and the rod.
26	**A**	B & C are incorrect as positive charges do not move. Without induction by the positively-charged rod and the migration of the electrons from the gold leaf and metal rod, excess positive charges cannot occurred at these two locations. Thus A precedes D.
27	**A**	In order for the comb to attract the iron fillings, electrostatic induction must take place. Electrons in the iron filings are induced by the charged comb which is electrically charged by friction.
28	**B**	P's end facing Q is a S-pole. R's end facing Q is also a S-pole. Both repel each other producing the field lines as shown. There are no field lines in between them so Q must not be a magnetic material
29	**D**	Applying Fleming's LHR, all are correct. For statement 3, an alternating current passing through the wire means that the direction is changing every half-cycle of the current.
30	**D**	All three conditions are needed for a larger force for a quicker rotation.
31	**B**	A slower moving magnet will produce a smaller induced emf. Since the N-pole is moved away from the same end of the coil, the induced emf will be opposite to that when it is moved in by Lenz's Law.
32	**D**	*Vs/Vp* = 240 V/ 15 V = 16. D has the correct turns ratio.
33	**A**	Angle of incidence at the boundary = 90 ^{o} – 38 ^{o} = 52 ^{o} The critical angle must be less than 52 ^{o} for TIR to take place. n = 1/ sin c 1.24 = 1/ sin c c = 54 ^{o} Hence 1.24 cannot be the refractive index of the medium.
34	**B**	n = 1/ sin c 1.4 = 1/ sin c c = 45.6 ^{o} Hence the minimum value of θ is 46 ^{o}
35	**C**	C is on the right of the page so it is laterally inverted. The letter i is symmetrical so there is no lateral inversion.
36	**A**	Object at B produces an enlarged image; Object at C produces image at infinity, image size is undefined ; Object at D produces a virtual enlarged image.
37	**B**	PQ – shows the point 3 moving to a position of maximum displacement, hence PQ is the amplitude. RS – is the distance between the centre of compression to the centre of rarefaction which is half of a wavelength.
38	**A**	T = 2.5 ms x4 = 0.01s $f = 1/T$ = 100 Hz $v = f \times \lambda$ = 100 x (2 x 7.5) v = 1500 m/s distance= 1500 x 0.10 = 150 m
39	**D**	Frequency of the sound does not change as the instruction source did not change. As sound enters into water, it speeds up and since $v = f \times \lambda$, λ increases.
40	**C**	Few cm of lead must be used to contain gamma rays as they are the most penetrating.

PAPER 2 SECTION A (50 marks)

Qn	Part	Answer	Remark
1	**(a)**	There is a reaction time between seeing the obstruction and stepping on the brakes. This translates to some distance moved by the car before decelerating.	
	(b)	It travels at a constant speed (for 1.0 s) followed by a decreasing speed (for 3.5 s) and then comes to complete rest (for the last 0.5s)	
	(c)	Speed = 20 m/0.9 s = 22 ms^{-1} (2 s.f.)	
	(d)(i)	There is an additional resistive force, air resistance. From Newton's 2nd law, deceleration = $F+F_{air}$ / m will be greater than F/m .	
	(ii)	Air resistance decreases as speed decreases. From $F+F_{air}$ / m , a decreasing F_{air} will a non-constant deceleration.	
2	**(a)(i)**	Moments of the sign's weight about P = 3.4 x 10^3 kg x 10 Nkg^{-1} x 0.5 m = 1.7 x 104 Nm	No mark for non-conversion of mass to weight
	(ii)	Taking moments about P and applying P.O.M. W_{block} x 2.0 m = 1.7 x 10^5 Nm ® W_{block} = 8500 N	
	(b)	The sign will rotate clockwise about P/topple as there is no anticlockwise moment to prevent the rotation/ a net clockwise moment	
	(c)	The CG of the block is now nearer the pivot P, thereby reducing the anticlockwise moment. There will be a net clockwise moment and the sign will rotate about P. The suggestion is thus incorrect	
3	**(a)**	From C to D the cord starts to stretch, causing the tension in the cord to increase. Tension is greater than the weight, resulting in an upward resultant force causing him to decelerate. As the cord stretches, tension increases which causes the upward resultant force to increase, hence causing an increasing deceleration.	
	(b)	Position C : KE = 5000 J Position D : 20000 J	
	(c)	Let h be the height between A and C. (50 kg)(10 Nkg^{-1})(h) = 5000 J ® h = 5000 /500 m = 10 m	
4	**(a)(i)**	Pressure at 0.028 m = (1.02 x 10^5 + 0.028 x 1500 x 10)Nm^{-2} = 102420 Nm^{-2} = 1.0 x 10^5 Nm^{-2} (2 s.f.)	
	(ii)	Force = 1.0 x 10^5 Nm^{-2} x 0.040^2 m^2 = 160 N = 1.6 x 10^2 N(2 s.f.)	e.c.f. from (i)
	(b)(i)	There is no resultant force acting [1]. Thus the weight of the cube = upward force exerted by the liquid [1] To ensure this, the pressure at the bottom face must always be kept at 102420 $Nm^{-2,}$ thus the height difference between the liquid surface and the bottom face must always be 0.028 m.	
	(ii)	Energy is lost through due to water moving through the pipes / work done in lifting/raising the water (level)	
5	**(a)**	It is the angle of incidence in the optically denser medium when the angle of refraction in the optically less dense medium is 90 degrees.	

	(b)	From n = 1/sin C = 1/sin 24° = 2.46	
	(c)	First diagram shows the refracted ray emerging at 57° to the vertical. [1] 2nd diagram shows total internal reflection within the diamond and the emergent ray parallel to the incident ray. [2]	All angles to be shown to warrant full credit.
6	**(a)**	● Thermal energy from the Sun is carried via infra-red waves/transmitted via radiation and transferred to the road molecules. ● Road molecules (at the surface) vibrate faster, increasing their kinetic store. ● Thermal energy transmitted via conduction throughout the road surface /This vibrational energy is passed on from molecules to molecules, thus warming up the road.	
	(b)	● The air molecules gain the thermal energy and move with higher velocity/ increasing the kinetic store. ● They move further apart, thereby decreasing the density of the air/increasing the internal potential store.	
7	**(a)**	The (fixed) temperature when a liquid changes into the gaseous state.	
	(b)(i)	From $E = IVt$ = 13x 230x 60 J = 1.79 x 10^5 J = 1.8 x 10^5 J (2 s.f.) [1]	
	(ii)	From $Q = mc\otimes($ 1.79 x 10^5 J = m (4200 J/kg°C) 78°C ® m = 0.546 kg [1] Rate of flow = 0.546 / 60 kgs^{-1} = 9.1 x 10^{-3} kgs^{-1} or 9.1 gs^{-1} [1]	Accept 0.54 kg/min
	(c)(i)	If the live wire is loose and touches any metal part of the heater, the earth wire will draw the current away from the user.	
	(ii)	If there is a current surge which exceeds the fuse rating, the fuse will melt/blow thereby cutting off any current path to the appliance.	
8	**(a)**	Thermistor	
	(b)(i)	R_{total} = (1/15+1/30)$^{-1}$ + 20 Ω = 30 Ω	
	(ii)	I = 6.0/30 A = 0.20 A	
	(c)	The thermistor's resistance decreases with increasing temperature. $R_{parallel}\downarrow \Rightarrow R_{total}\downarrow$. Thus ammeter reading increases.	
9	**(a)(i)**	These are nuclear radiations in an environment where no radioactive source has been deliberately introduced.	
	(ii)	Background radiations are random in direction and is not constant at any instant.	
	(iii)	Average count rate = 33 counts per minute.	
	(b)(i)	β and γ	
	(ii)	Aluminium sheet stops β-particles and causes the reading to drop from 976 to 117 counts/min. Lead stops some γ-radiation, causing the reading to drop from 117 to 52.	
	(iii)	$^{60}_{27}Co \rightarrow {}^{60}_{28}X + {}^{0}_{-1}\beta + {}^{0}_{0}\gamma$	Accept $^{0}_{-1}e$
	(c)(i)	Time taken for half of the nuclei of a radioactive nuclide to decay.	

	(ii)	1. The count rate includes background count and radiation from other sources not from cobalt-60 since the lead sheet has blocked the ©-radiation. 2. The non-constant count rate is due to the different directions which explains the variation in the count rate as the detector is only placed in one direction.	Accept spontaneous
10	**(a)**	The magnetic flux linkage with the coil is changing as the coil rotates . From Faraday's Law, this will induce an electromotive force (e.m.f.) in the coil.	
	(b)	Maximum emf generated when the plane of the coil is parallel with the magnetic field/horizontal. Reason:Rate of change of flux linkage is the maximum when the angle between the plane and the direction of motion of the coil is the maximum at 90°	
	(c)	**EITHER** : Energy supplied to lamp is lost through IR radiation and light. Student has to do more work/supply more energy and make up for the loss. Hence the need to apply greater force to do work. **OR** : Before switch is closed- no induced current flows. When switch is closed - extra work needs to be done to move a unit charge through the circuit to light up the lamp/overcome the lamp's resistance. This is provided by the greater force applied. **OR** : There is a potential difference across the lamp due to the lamp's resistance. The current need to lit up the lamp is higher than without a lamp. A greater rotating force is thus needed to produce a larger rate change of flux linkage and hence a larger e.m.f. can drive a unit charge across the lamp.	
11	**EITHER**		
	(a)	▪ The ac current in coil Y produces a changing magnetic field, the strength of which is enhanced by the soft iron bar. ▪ This changing magnetic field is linked to coil X. ▪ The changing flux linkage in coil X produces an induced emf . An induced current flows and recharge the cell.	
	(b)	Diode in the circuit allows current to flow in one direction, In every cycle of the induced current flowing in coil X, only the power delived in a ½ cycle is utilised to recharge the cell as the other half cycle is cut-off by the diode. The charging is thus only 50% efficient.	
	(c)	The voltage is stepped down from 220 V to 1.2 V.	
	(d)	Applying $\frac{N_s}{N_p} = \frac{1.2\ V}{220\ V} \Rightarrow \frac{N_s}{N_p} = 0.0055$	Accept $\frac{N_p}{N_s} = 183$
	(e)	The wires in the charging unit and the toothbrush are housed inside plastic casings. Such double insultation does not require an earth wire.	
	(f)	Power = 1.8 x 1.2 W = 2.16 W = 2.2 W (2 s.f.)	
11	**OR**		
	(a)(i)	▪ The alternating current in the coil created a varying magnetic field. ▪ This changing field interacts with the cylindrical magnet and produces an alternating force, which then moves the cone.	
	(ii)	From $v = f\lambda$	

		$\Rightarrow \lambda = 320\ ms^{-1} / 500\ s^{-1}$ $= 0.64\ m$	
	(b)(i)	▪ As sound energy travels through both medium, it causes the particles of the medium to oscillate parallel to the direction of the propagation of the sound. ▪ This motion of the particles creates of regions of compressions and rarefactions. ▪ The sound is thus transmitted via these compressions and rarefactions from the source.	
	(ii)	1. Difference in the loudness of sound heard 2. Difference in the time the sound reaches the swimmers.	
	(c)	▪ When he pushes his feet against the wall, the wall pushes back on his feet. This reaction force launches the swimmer to the right. ▪ Since he is swimming in water, there is a drag force/water resistance acting on him. ▪ The reaction force acted by the wall on him is greater than the drag force/water resistance producing a resultant force and hence an initial acceleration.	