2024 4E Physics Prelim Exam Solution

Paper 1

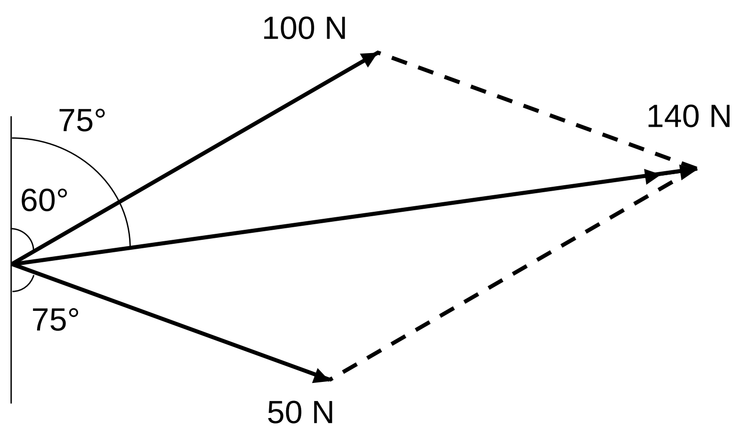
Multiple Choice Questions [40 marks]

1	D	**11**	A	**21**	D	**31**	B
2	C	**12**	B	**22**	D	**32**	A
3	B	**13**	B	**23**	C	**33**	B
4	A	**14**	C	**24**	D	**34**	B
5	A	**15**	D	**25**	D	**35**	B
6	C	**16**	A	**26**	C	**36**	D
7	A	**17**	C	**27**	B	**37**	C
8	C	**18**	A	**28**	D	**38**	D
9	D	**19**	B	**29**	B	**39**	B
10	A	**20**	B	**30**	C	**40**	B

Paper 2

Note:
Deduct one mark overall for incorrect significant figures.
Deduct one mark overall for no unit or incorrect unit.

Section A: Structured Questions [70 marks]

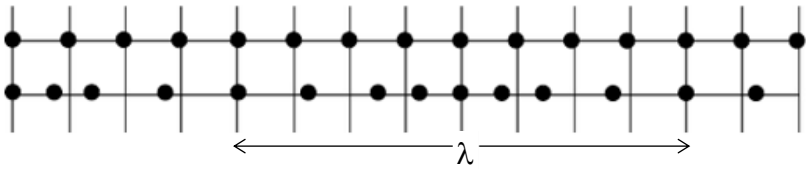
Qn	Solution	Mark
1(a)	Let 1 cm represent 10 N.  - correct vector diagram - resultant force = 140 N (accept 138 N – 142 N)	 [1] [1]
1(b)	140 = 8.0a a = 17.5 m/s^2	 [1]
1(c)	$17.5 = \frac{v-0}{6.0}$ $v = 105$ m/s	[1]
2(a)(i)	Moment = 110(0.05) = 5.5 N m (or 550 N cm)	[1] [1]

2(a)(ii)	The perpendicular distance from the line of action of *F* to B is 8.0 cm, while the perpendicular distance from *F* to A is zero. Hence the moment of *F* applied at B will be greater than the moment of *F* applied at A (which is zero).	[1]
2(b)	When the boy raises his left foot off the ground, his weight will produce a clockwise moment about his right foot (i.e. the pivot), which causes him to topple. (Note: the rightward horizontal force which the wall initially exerts on the boy's arm also produces a clockwise moment about his right foot).	[1]
3(a)	Pressure = $640/(2.0 \times 10^{-4})$ $= 3.2 \times 10^{6}$ Pa	[1] [1]
3(b)	Pressure exerted by oil on piston B = 3.2×10^{6} Pa Force on piston B = $(3.2 \times 10^{6})(15 \times 10^{-4})$ = 4800 N	[1] [1]
3(c)	I do not agree. If the cross-sectional area of cylinder D is less than 2.0 cm^2, the force exerted by piston B on the brakes will be less than 4800 N. To produce the same force of 4800 N, the force exerted by the driver's foot on the brake pedal would have to be much larger, which may not be feasible (Or: the car will take a longer time to come to a stop).	[1] [1]
4(a)	GPE = (1.2)(10)(7.5) = 90 J	[1] [1]
4(b)	GPE of ball at max height of 10 m = (1.2)(10)(10) = 120 J By conservation of energy, $120 + 25 = 90 + ½ (1.2)(v_o)^2$ v_o = 9.57 m/s	[1] [1] [1]
4(c)	Air resistance is negligible. (Any other valid answers)	[1]
5(a)	Depth of sea = speed of sound x time = 1200 x 0.75 / 2 = 450 m	[1] [1]
5(b)	The sound transmitter causes water particles near it to vibrate to and fro in the direction parallel to direction of wave travel, forming regions of compression and rarefaction, as energy is transferred through the water as longitudinal sound waves.	[1] [1]

5(c)(i)

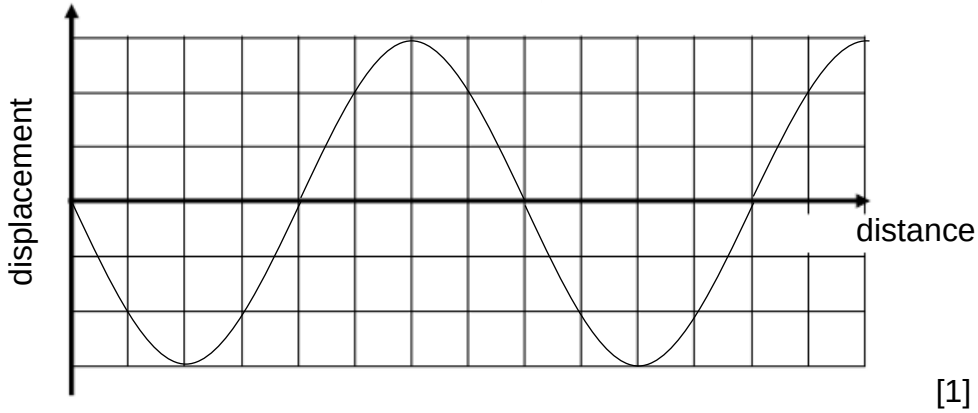
Fig. 5.1a

Fig. 5.1b



[1]

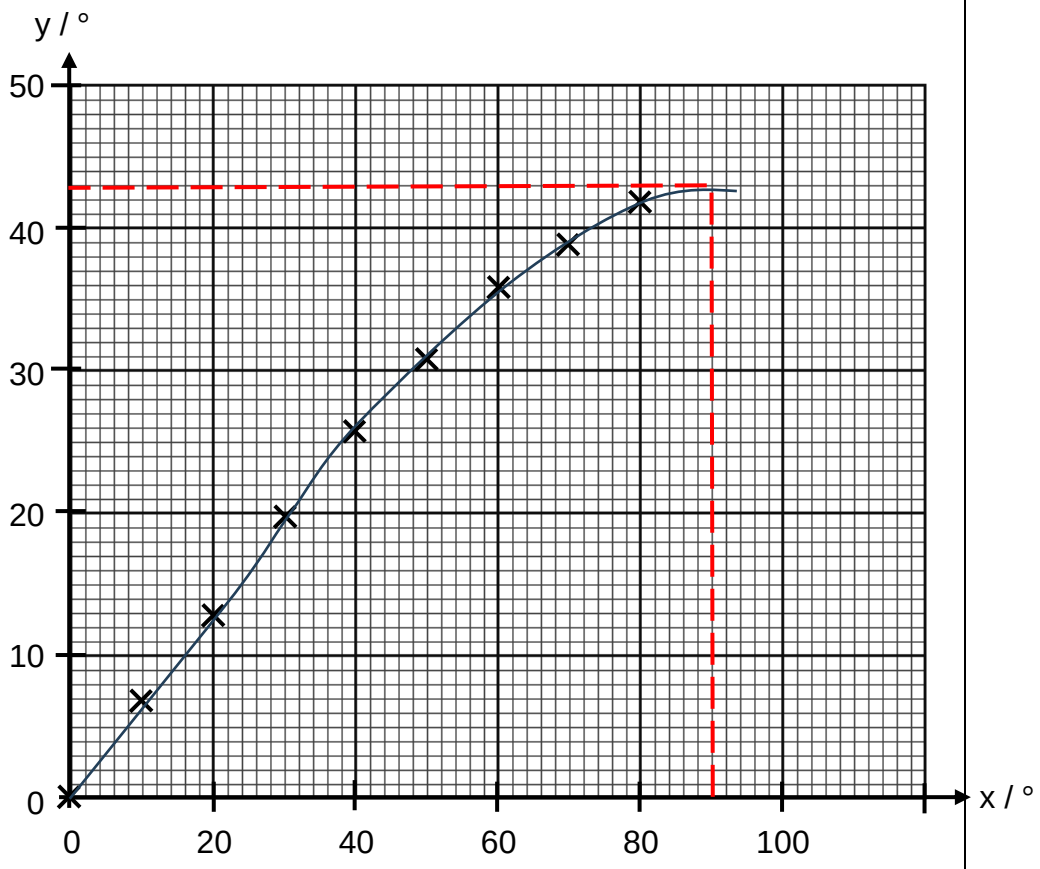
5(c)(ii)



[1]

Fig. 5.2

6(a)

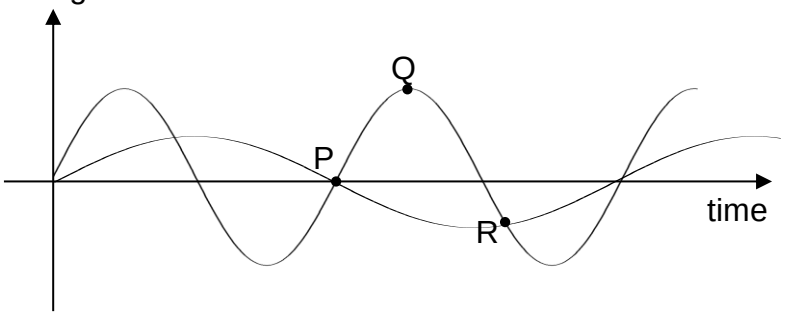


Correct plotting of all points. [1]
Correct best fit curve. [1]

6(b)

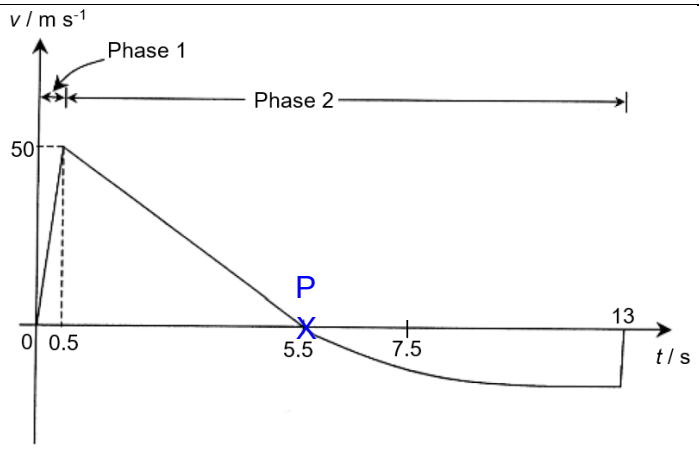
The critical angle is the angle of incidence (in glass) for which the angle of refraction (in air) is 90°. [1]
From the graph, when x = 90°, critical angle (y) is 43°. [1]

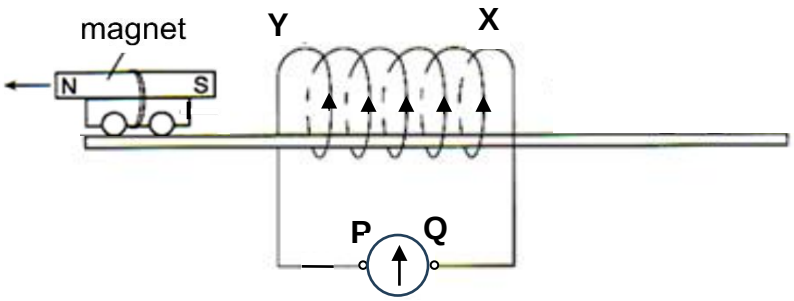
6(c)(i)	The second graph will also be a curve but will lie below the first graph.	[1]
6(c)(ii)	The critical angle obtained from the second graph will be smaller.	[1]
7(a)	The charge on the ball is positive. Hence it is repelled from the positively charged plate and attracted to the negatively charged plate.	[1]
7(b)	When the positively charged ball touches the negatively charged plate, electrons flow from the negatively charged plate to the ball and the ball becomes negatively charged. The ball is repelled from the negatively charged plate and comes into contact with the positively charged plate, hence it becomes positively charged. The ball is then repelled from the positively charged plate to the negatively charged plate. As a result, ball will oscillate between the plates.	[1] [1] [1]
8(a)	When the current is more than 10 A, the magnetic field created by the electromagnet is stronger, and the electromagnet will induce stronger magnetism in the iron bar. The end of the iron bar nearer to the electromagnet will have an opposite pole compared to the end of the electromagnet near it. This causes the iron bar to be attracted to the electromagnet and it is lifted up, which breaks the contact points. The circuit is thus open and current stops flowing.	[1] [1] [1]
8(b)	Have more turns in the coil Place the electromagnet nearer to the iron bar Use an iron bar with a smaller mass	[1]
9(a)	Position P. Fig. 9.1 shows the coil in a vertical position which is just about moving parallel to the magnetic field lines of the magnet. There is no cutting of the magnetic field lines and hence the induced voltage is zero.	[1] [1]

9(b)	voltage  Correct graph drawn with: half the amplitude, and half the frequency	 [1] [1]
10(a)	$^{241}_{95}\text{Am} \rightarrow {}^{237}_{93}\text{Np} + {}^{4}_{2}\text{He}$	[1]
10(b)	Since americium-241 has a much longer half-life, the <u>smoke detector</u> that uses it can <u>function for a much longer time without requiring the replacement of the radioactive source</u>.	[1]
10(c)	$1.0 \times 10^{11} = 8.0 \times 10^{11}\left(\frac{1}{2}\right)^{n}$ $n = 3$ $\text{Time} = 3(430)$ $= 1290 \text{ years}$	[1] [1]
10(d)(i)	1. It can kill/damage cells. 2. It can cause mutation of cells. 3. It can cause cancer. (Any other valid answers)	[1]
10(d)(ii)	1. The radioactive source will be further away from the body, so less radiation will reach the body. 2. The alpha particles will be stopped/reduced by air, so less radiation will reach the body.	[1]
11(a)	The specific heat capacity of a material is the <u>amount of thermal energy required to raise the temperature of a unit mass of the material by 1 K</u> (or 1 ^{o}C).	[1]
11(b)	Frying pans are made of materials with a low specific heat capacity so that the pans will have a <u>significant temperature rise</u> for a given amount heat supplied. This would enable the food to be cooked faster.	[1]
11(c)	Copper	[1]

11(d)(i)	For hot plate A: Pt = mc$\Delta\theta$ 600 t = 4.0 x 385 x (150 – 30) t = 308 s For hot plate B: Pt = mc$\Delta\theta$ 1200 t = 2.5 x 897 x (150 – 30) t = 224 s For hot plate C: Pt = mc$\Delta\theta$ 900 t = 3.0 x 466 x (150 – 30) t = 186 s	[1] [1] [1]
11(d)(ii)	1. Melting point of the material 2. Whether the material is non-stick Accept any valid answer.	[1]
11(e)(i)	Copper is a much <u>better conductor of heat</u> than stainless steel. Hence, heat from the hot plate will be transferred to the food faster when the saucepan has a copper base.	[1]
11(e)(ii)	The <u>stainless steel body</u> of the saucepan would <u>feel colder to touch</u> than its handle. This is because <u>steel is a better conductor of heat than plastic</u>. Hence the <u>body heat from the boy is conducted away from him</u> more quickly by the stainless steel.	[1] [1]
12(a)(i)	e.m.f. = $(2.0 \times 10^{-3})(2000)$ = 4.0 V	[1] [1]
12(a)(ii)	Current in 4000 Ω resistor = 4.0/4000 = 1.0 mA Total circuit current = 2.0 + 1.0 = 3.0 mA	[1] [1]
12(a)(iii)	Energy = $(2.0 \times 10^{-3})^2(2000)(5.0 \times 60)$ = 2.4 J	[1] [1]
12(b)(i)	Resistance of X = 800 Ω p.d. across $Y = \left(\frac{1000}{1000+800}\right)(12)$ $= 6.67$ V	[1] [1]
12(b)(ii)	When the temperature rises, the <u>resistance of X decreases</u>. By the potential divider principle, the <u>potential difference across resistor Y increases</u>.	[1]
12(b)(iii)	When the <u>current</u> flowing in the circuit <u>exceeds the fuse rating</u>, the <u>fuse will blow</u> and <u>disconnect the circuit</u>. This helps to protect the circuit components from damage.	[1]

Section B: Structured Questions [10 marks]

Qn	Solution	Mark
13(a)	$F - 80(10) = 80\left(\frac{50}{0.5}\right)$ $F = 8800$ N	[1] [1]
13(b)		[1]
13(c)	Max height = ½ (5.5)(50) = 138 m	[1] [1]
13(d)(i)	From t = 5.5 s to 7.5 s, the dummy falls with its speed increasing at a decreasing rate (or falls with decreasing acceleration). This is because as it falls, air resistance acting on the dummy and its parachute acts upward, so the resultant force acting downward on the dummy is less than its weight. Hence the dummy accelerates downward with an acceleration that is less than 10 m/s^2. As the speed of the dummy increases, air resistance acting on it increases, so the resultant downward force acting on it decreases. Hence its acceleration decreases.	[1] [1] [1]
13(d)(ii)	Eventually the magnitude of the air resistance acting on the dummy is equal to the weight of the dummy. Hence the resultant force acting on the dummy is zero, so the acceleration of the dummy is zero and it falls with a constant velocity until it reaches the ground.	[1] [1]
14(a)	The trolley moves away from the coil.	[1]
14(b)	When the switch is closed, the right-hand side of the coil is magnetised with a north pole. This repels the north pole of the magnet on the trolley, which moves away from the coil.	[1] [1]

14(c)(i)	The current in the coil is reversed and the right-hand side of the coil is magnetised with a south pole. Since unlike poles attract, the trolley carrying the magnet will move towards the coil.	[1] [1]
14(c)(ii)	The trolley will still move away from the coil. However, it will move with a greater speed because the electromagnet is stronger and hence the repulsion of the magnet from the electromagnet will be stronger.	[1] [1]
14(d)(i)	As the magnet approaches the coil at X, there is a change in the magnetic flux linking the coil. An e.m.f is induced across the coil and hence there is an induced current in the coil.	[1]
14(d)(ii)	North pole	[1]
14(d)(iii)	Upward  	[1]