2024 Sec 4 Express Preliminary Examinations Answers

Paper 1 MCQ [40 marks]

1	2	3	4	5	6	7	8	9	10
A	A	D	C	C	C	B	A	A	B

11	12	13	14	15	16	17	18	19	20
B	D	A	A	C	A	A	D	D	B

21	22	23	24	25	26	27	28	29	30
B	C	C	B	D	D	B	D	C	A

31	32	33	34	35	36	37	38	39	40
C	B	A	B	A	D	A	D	A	B

Paper 2 Section A [70 marks]

1 **(a)** $P = h\rho g + P_{atm}$
$= (3.0)(950)(10) + 101\,000$ [M1]
$= 130\,000$ Pa (130 kPa) [A1] accept equivalent units

(b) As the oil leaves the container, the weight/height of the oil above the crack decreases. [1]
This lowers the force acting at that point per unit area, thereby lowering the pressure.
The oil hence moves nearer to the container. [1]

2 **(a)** $V = 3.2 \times 0.35 \times 0.025$ [M1]
$= 0.028\ m^3$
$P = 24 / 0.028$
$= 860\ kg/m^3$ (accept 857 kg/m^3) [A1]

(b) (ACW) moment due to weight of plank = 24(10)(1.3) [M1]
= 312 Nm
By principle of moments,
$M_{ACW} = M_{CW}$
F(2.6) = 312 [M1]
F = 120 N [A1]

(c) As the man walks to the right, his weight produces a clockwise moment **[1]** about the right hand support.
This causes the plank to turn clockwise and the plank/man/both will topple **[1]**

3 **(a)** Waves transfer energy without the transfer of particles/matter [1]
A longitudinal wave travels parallel to the direction of vibration. [1]

(b) Ultrasound waves have more energy [1] (and can be hence detected more easily)
Accept: reflected more efficiently when encountering tissues, not absorbed/scattered easily

(c) Time taken = 0.03 ms [M1]
Distance = $1500(0.03 \times 10^{-3})(0.5)$
= 0.023 m (accept 0.0225 m) [A1]

4 (a) (i) Refractive index, η = 1/sin(38°) [M1]

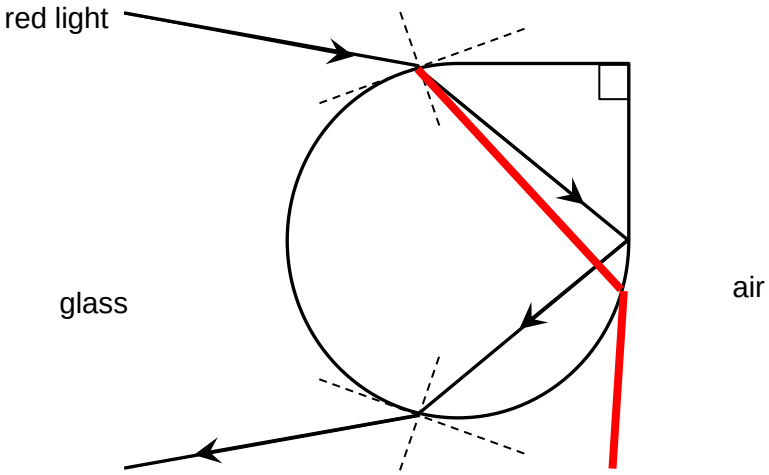
= 1.6243

η = c / v

v = (3 x 10^8) / 1.6243

= 1.8 x 10^8 m/s (accept 1.85 x 10^8 m/s) [A1]

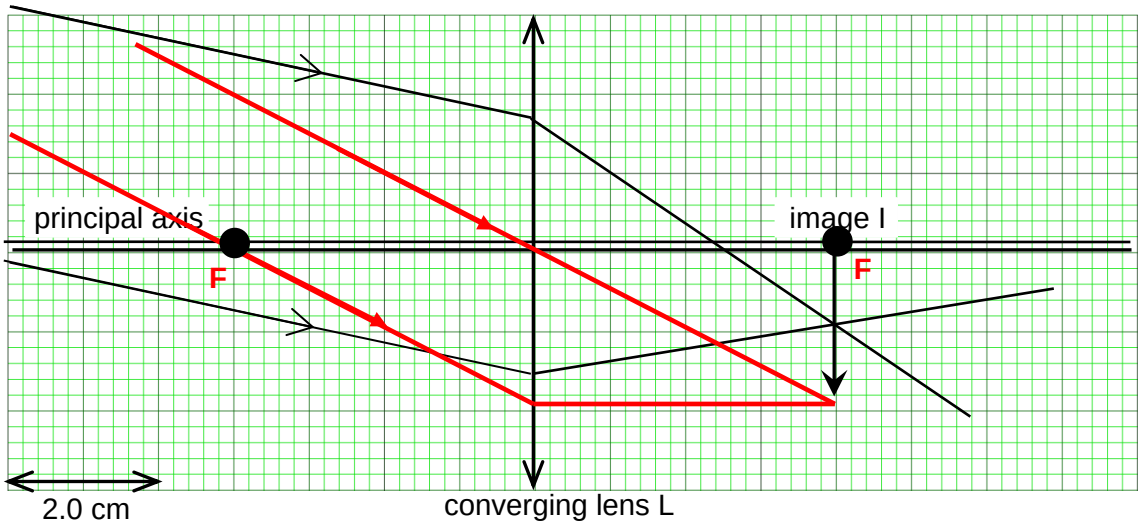
(ii)



[B1]

(b) (i) The light rays incident on the lens are <u>parallel</u> [1]

(ii)



Focal point (either side) [1]

Ray passes through optical centre undeviated [1]

Ray parallel to first ray, passes through lens, becomes horizontal [1]

Deduct [1] for missing arrows

5 **(a)** **(i)** Copper is a good conductor of heat and will transfer energy from the water quickly. [1]

(ii) This increases the surface area which the water is exposed to, thereby allowing more energy to be absorbed from the water. [1]

(iii) As the water is cooled, it contracts, becomes denser and sinks. [1]

The warmer water below, being less dense, rises. [1]

(This sets up convection currents and causes the water to mix together.)

(b) Energy removed = $mc\Delta\theta$

= (0.25)(4200)(25 – 10) [M1]

= 16 000 J (accept 15 800 J) [A1]

(c) The water molecules are in continuous motion. The more energetic molecules near the surface of the water gain energy from the surroundings. [1]

Eventually, they gain enough energy to overcome the forces of attraction/break the bonds, allowing them to escape the liquid. [1]

6 **(a)** **(i)** R_{LDR} = 2000 Ω

Total R = 6000 + 2000 [M1]

= 8000 Ω

Current, I = V/R

= 12/8000

= 0.0015 A [A1]

(ii) V = 6000/(6000+2000) x 12

= 9.0 V [A1]

(b) As light shines on the LDR, its resistance decreases (gradually to 200 Ω) [1]

This increases the current through the circuit (as I = V/R). The p.d. across the 6 kΩ resistor hence increases from 9.0 V (to 11.6 V). [1]

7 **(a)** 6.0 V

(b) Open switch/Diode (in reverse bias)/(Ideal) voltmeter/battery with opposite polarity

No current flows through the circuit. [1]

(c) **(i)** V = IR

= 0.40(30)

= 12 V

(ii) Battery (with emf 6.0 V)

When the polarities of the 6.0 V battery were reversed, current can once again flow. In addition, the p.d. across the resistor is more than what the original battery can supply, indicating the presence of a second battery.

8 **(a)** When switch S is closed, current flows through the solenoid and it becomes an electromagnet. [1]

The electromagnet attracts the (short arm of the) iron armature, causing it to turn clockwise about the pivot. [1]

The (long arm of the) iron armature pushes the flexible contacts together until they touch, closing the circuit with the headlamp and allowing current to flow through the lamp. This allows the lamp to light up. [1]

(b) If a steel armature were used, there will be delays in turning off the lamp/the lamp cannot be turned off. This is because steel does not demagnetize as easily. [1]

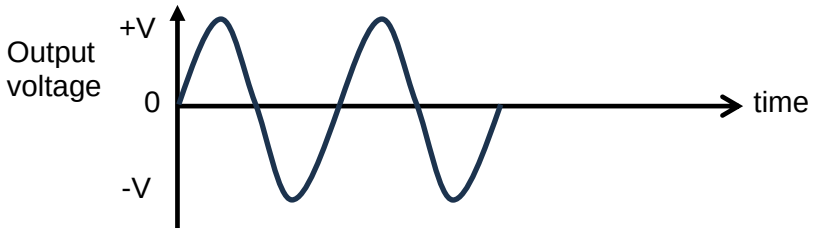
9 **(a)** When the torch is shaken, the magnet moves into and out of the coil. This causes a change in magnetic flux in the region of the coil. [1]
There is an induced emf in the coil by Faraday's Law. [1]
The induced emf causes a current to flow through the bulb, allowing it to light up. [1]

(b) As the magnet moves through the coil, there will be short moments where the magnet stops moving. In these instances, there is no changing magnetic flux, and emf will not be induced. [1]

(c) The light produced will be brighter. [1]

(d) [1] Graph with appropriate axes (output voltage against time) and labels

[1] sinusoidal graph



10 **(a)** **(i)** Similarity: They have the same number of protons

Difference: They have different number of neutrons/nucleons **both for [1]**

(ii)

$$^{239}_{94}Pu \longrightarrow \underset{[1]}{^{235}_{92}U} + \underset{[1]}{^{4}_{2}\alpha}$$

(iii) $1.2 \times 10^5 = 5$ half-lives [M1] accept similar working

Count rate = $6400 / 2^5$

= 200 counts/second [A1]

(b) **(i)** Nuclear fission is a process in which the nucleus of an atom splits (usually into two parts) and releases a large amount of energy. [1]

(ii) Nuclear power is a clean source of energy / Nuclear power produces much more energy compared to gas of the same mass / *Accept other plausible answers* [1]

11 (a) The gradient of the graph is constant. [1]

(b) (i) Displacement = area under the graph

= (1/2)(3.4)(3 – 2) – (1/2)(6.8)(2 – 0) [M1]

= - 5.1 m

Magnitude = 5.1 m [A1]

Direction = downwards / below start point [A1]

(ii) Acceleration = (v – u) / t

= (3.4 – 0) / 1 [M1]

= 3.4 m/s^2 [A1]

(c) F_{net} = m(3.4)

= 15/10 x (3.4) [M1]

= 5.1 N

Upward force = 15 + 5.1

= 20.1 N [A1]

(d) When *T* is 15 N, the resultant force acting on the block is zero. [1]

By Newton's first law, the block will be moving at constant speed. [1]

(e) The force exerted by the block on the Earth, equal in magnitude and opposite in direction/acting upwards [1]

Section B [10 marks]

12 (a) (i) Energy that can be replenished/does not get used up/can be regenerated easily [1]

(ii) Singapore does not have the land space to build a dam. (Accept other plausible answers) [1]

(b) (i) 1. Energy output = 6.4 x 10^9 x 3600 x 24

= 5.5 x 10^{14} J (accept 5.53 x 10^{14} J) [A1]

2. Depending on environmental factors like seasons and climate, the flow of water may not be enough to allow the dam to operate at full capacity at all times. [1]

(ii) 1. GPE = mgh

= (1.6 x 10^{10})(10)(170) [M1]

= 2.7 x 10^{13} J (accept 2.72 x 10^{13} J) [A1]

2. P = E/t

= 2.7 x 10^{13} / 3600

= 7.5 x 10^9 W

Alternative: E = Pt

= (6.4 x 10^9)(3600)

= 2.3 x 10^{13} J [M1]

Efficiency = 6.4 x 10^9 / 7.5 x 10^9 x 100%

= 85% [A1]

3. 1. There is still some energy in the kinetic store as the water continues to flow after passing through the dam [1]

2. Some of the energy is transferred into the internal store of the surrounding [1]

13 **(a)** When the resistance of the variable resistor is increased/reduced, the current is reduced/increased [1]

This reduces/increases the power of the fan, thereby adjusting the fan's speed. [1]

(b) Total P = 1000 + 60(3) = 1180 W

E = Pt

= 1.18 kW x 4 x 7 [M1]

= 33.0 kWh

Cost = 33.04 x $0.32

= $10.60 (accept $10.57) [A1]

(c) The fuse protects the appliance in the event of an electrical fault. When current is too high, the fuse blows and disconnects the appliance. [1]

The fuse needs to be connected to the live wire so that when it blows, it will disconnect the appliance from high voltage. [1]

(d) Current through 1 lamp = P / V

= 60 / 220 [M1]

= 0.27272 A

No. of lamps more = (3 / 0.27272) – 3

= 8 [A1]

(e) **(i)** Less energy is transferred to non-useful stores. / More energy is transferred to useful stores. [1]

(ii) Energy efficient bulbs reduce the cost of using electricity / conserves more electricity / helps the consumer be more environmentally friendly. [1]