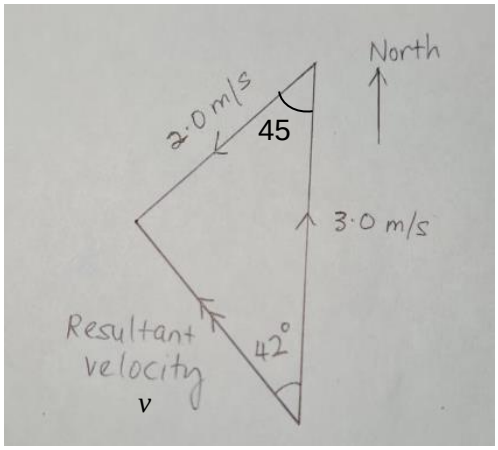
Sec 4 Express Physics Prelim Examination 2021 – Marking Scheme

Paper 2 Section A (50 marks)

Qn	Solutions	Mark Allocation
1(a)	Velocity is a **vector** quantity and hence it has a **magnitude (= 3.0 m/s**) and **direction** (which is **due North**).	A1
1(b)	scale : 1cm represent 0.5 m/s  magnitude = 2.2 m/s (± 0.2cm) direction = 42° due west from the North (± 2°) Alternative method: using cosine rule and sine rule respectively $v = \sqrt{2^2 + 3^2 - 2(2)(3)cos45°}$ = 2.1 m/s (sin θ / 2.0 = sin(45°) / 2.1 ⇒ θ = 42°) *the following will result in loss of marks* 1. *wrong orientation of the vector diagram* 2. *labelling length instead of velocity* 3. *did not indicate angles on vector diagram* 4. *drew solid lines unnecessarily* 5. *resultant velocity was not indicated with a double arrow* 6. *inappropriate scale used, resulting in a small diagram*	B1 (vector diagram constructed & labelled correctly) A1 A1
2(a)(i)	The moment of a force is the product of the force and the perpendicular distance from the pivot to the line of action of the force.	B1 Any symbols used must be defined.
2(a)(ii)	The filled buckets that cause moments about the axle are: buckets 2, 3 and 4.	A1

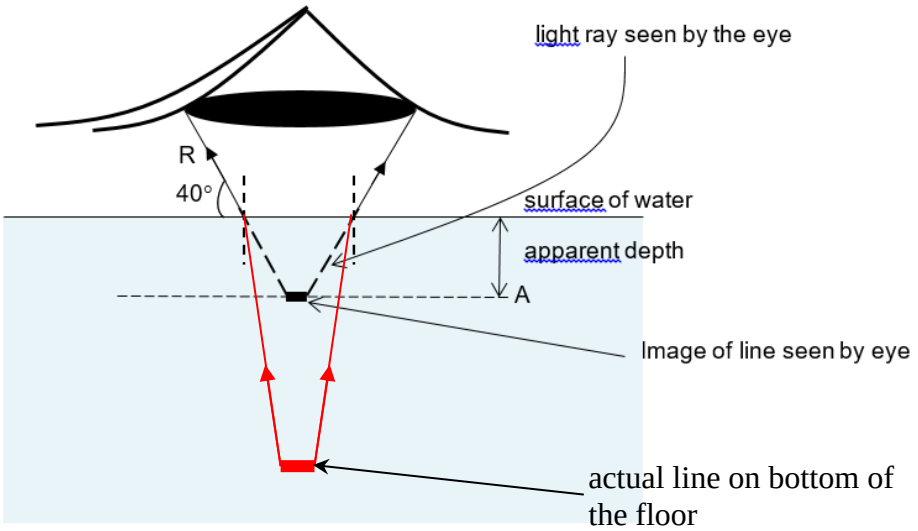
<table>
<tr><td>2(a)(iii)</td><td>The largest moment is provided by bucket 3
= (weight of water) x (perpendicular distance from the axle to the line of action of the weight)
= (40)(10) x (1.6)
= 640 Nm</td><td>M1

A1</td></tr>
<tr><td>3(a)</td><td>Insert the thermometer into a steam compartment with the bulb of the thermometer above boiling water. The stem of the thermometer with the marked upper fixed point should protrude from the top of the compartment. Use a manometer to check that the pressure inside the compartment is the same as the atmospheric pressure outside. When the level of the mercury in the thermometer stem remains steady, it indicates the upper fixed point which is the steam point.</td><td>B2

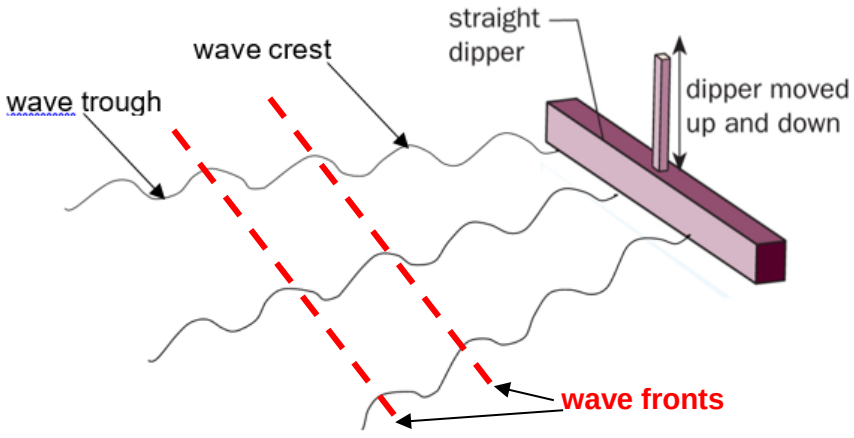
(deduct 1 mark for any omission of the three important points)</td></tr>
<tr><td>3(b)</td><td><table><tr><td></td><td>physical property that changes</td><td>substance or object involved</td></tr><tr><td>example</td><td>volume</td><td>a liquid</td></tr><tr><td></td><td>resistance

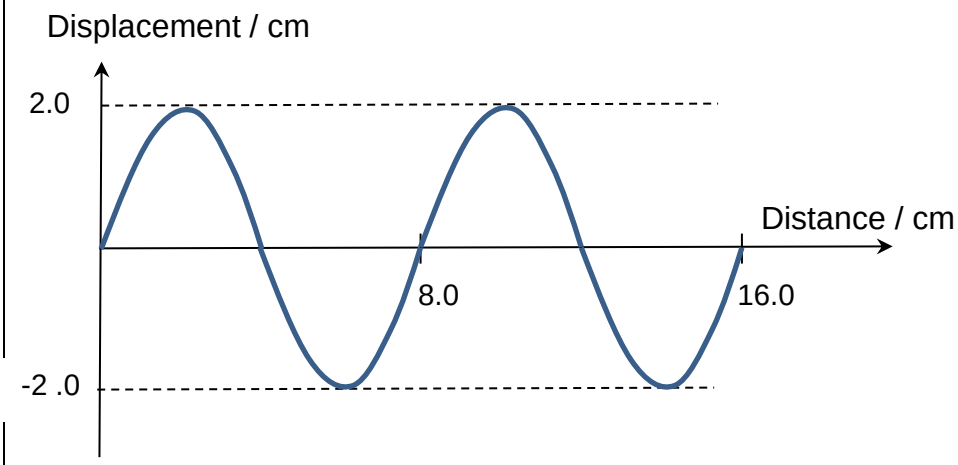
electromotive force (spelled out)</td><td>a metal

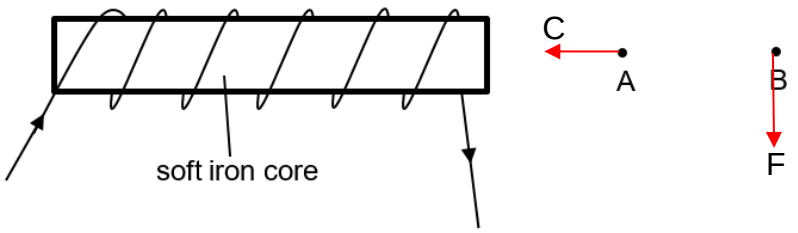
a thermocouple</td></tr></table></td><td>B1
(any one of the property and the corresponding substance)</td></tr>
<tr><td>3(c)</td><td>mass of water = m
Assumption: Heat lost by water = Heat gain by thermometer and no heat is lost from the water to the surrounding.
m x 4.2 x (90-82) = 2.5 x (82-20)
m = 4.6 g</td><td>M1

A1</td></tr>
<tr><td>(a)</td><td> 
</td><td>B2

(correct construction of the 2 incident rays from the line deeper down below the image, incident rays bent towards the normal, arrow</td></tr>
</table>

	(Note: Due to refraction, the image line appears shorter than the actual line.)	indicated on ray. Deduct 1 mark for any omission or mistake.)
4(b)	Since light travels from water to air, Refractive index of water n is given by $\frac{1}{n} = \frac{sin i}{sin r}$ (i = angle of incidence in water, r = angle of refraction in air) $\frac{1}{n} = \frac{sin i}{sin r}$ $\sin i = \frac{sin\,(90°-40°)}{1.33}$ $i = 35°$	C1 A1
4(c)	Light will bend towards the normal when it refracts at the water–oil boundary into the optically denser oil. It will then **bend further away from the normal as it refracts at the oil-air boundary into air** compared to the refracted ray emerging from a water-air boundary. This will cause the floor to look even shallower than before. Hence the **image of the line will appear above level A**.	B1 B1
5(a)(i)	Imaginary line on a wave that joins all **adjacent** points that are in phase.	B1
5 (a)(ii)		B1 wavefronts drawn correctly joining all crests (or troughs) across the waves

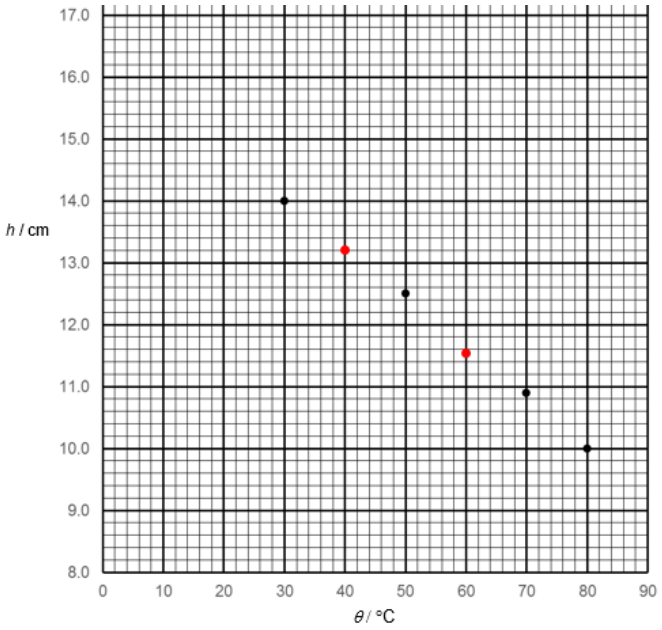
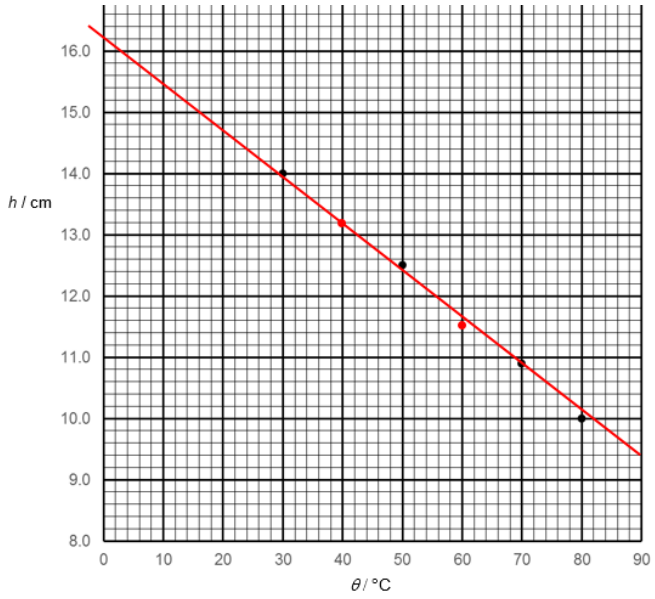
5(b)(i)	Frequency of the wave f = 5 cycles / 10 s = 0.5 Hz Wavelength of the wave λ = 8.0 cm = 0.080 m Speed of the wave $v = f\lambda$ = (0.5)(0.080) = 0.04 m/s	M1 A1
5(b)(ii)		B2 (drawn 2 wavelengths, labelling the amplitude and wavelength. deduct 1 mark for any mistake or omission)
6(a) (i)	The **lighter part of the image** on the paper **reflects more light onto the drum** and form a conducting area on the drum which **cause the positive charges to be discharged.**	B1 B1
6(a)(ii)	The **darker areas of the image reflect less light**. The **corresponding regions on the drum remain insulating**, and the positive charges remain on the surface of the drum.	B1 B1
6(a)(iii)	As **opposite charges attracts**, the **toner powder is negatively charged** and the **paper is positively charged**.	B1
6(b)(i)	As the paint leaves the nozzle of the spray gun, the paint droplets become **charged by friction**.	B1
6(b)(ii)	As **like charges repel**, the charged paint droplets will repel one another and spread out.	B1
6b(iii)	As the charged droplet spread out, it will form a **uniform coat of paint on the car body**. Or As the **paint droplets are charged**, it will **reach the car body which is earthed** (instead of falling on the floor) and in this way there will be less wastage of paint.	B1

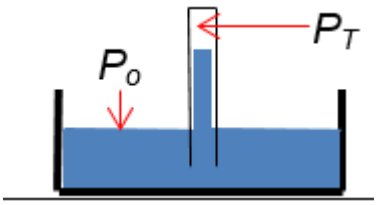
7(a)	(Resistance is the ratio of the p.d. across the LED to the current flow through it.) From **0 V to 2.7 V**, the current of the LED is zero, hence **its resistance is infinitely high**. From **2.7 V to 3.6 V**, the current flow through the LED increases drastically to a very high value, which indicates that **its resistance falls from an infinitely high value to zero**.	B1 B1
7(b)(i)	The *I-V* graph for the filament lamp **is not a straight line** passing through the origin.	B1
7(b)(ii)	The **resistance of the filament lamp changes (/does not remain constant)** due to the rise in temperature of the filament as current flows through it.	B1
7(c)	For the lamp, at V = 3.0V, I = 37 mA 4 resistance = $\frac{3.0\ V}{37 \times 10^{-3}\ A}$ = 81 Ω	M1 A1
7(d)	In a series circuit, the same current (37 mA) flows through the LED and the resistor. From the *I-V* graph for the LED, I = 37 mA, p.d. across LED, V_D = **3.4 V** Using $V = IR$, p.d. across R, V_R = (37 x 10^{-3})(200) = **7.4 V** Hence e.m.f., E = (p.d. cross lamp) + V_D + V_R = 3.0 V + 3.4 V + 7.4 V = **13.8 V**	C1 C1 A1
8(a)(i), (ii)		B1 (C) B1 (F)
8(a)(iii)	Using **Fleming's Left-Hand rule**, the **fore finger which indicates magnetic field, points to the left**. The **middle finger which indicates conventional current (flow of positive charges), points perpendicularly out of the plane of the paper** and the **thumb which indicates the force, points down.**	B2 (deduct 1 mark for any missing point)
8(b)(i)	Clockwise rotation of the coil means that a pair of forces acts on the side AB and CD of the coil. Consider the side AB of the coil, the **magnetic force acts upwards** and the **current flow from A towards B**. Using	B1 (explain using FLH rule on side

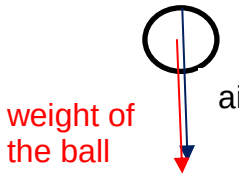
	Fleming's Left-Hand rule, with the thumb pointing in the direction of the force (up) and the middle finger pointing in the direction of the current flow (A to B); the fore finger which indicates **the direction of the magnetic field is found to point towards the magnetic pole P**. Hence magnetic pole **P is the South pole** and magnetic pole **Q is the North pole**.	AB or CD of coil) A1
8(b)(ii)	As the **coil rotates past the vertical position by half a turn**, the **current through side AB of the coil reverses direction** (flow from B to A) as its split-ring commutator now makes contact with brush Y. By Fleming's Left-Hand rule, **the magnetic force on side AB acts down** and continue to rotate the coil in the clockwise direction.	B1 B1

Paper 2 Section B (30 marks)

If both questions in **11** are attempted, only the first question is marked

Qn	Solutions	Mark Allocation
9(a)(i)		B1 (Points plotted correctly)
9 (a)(ii)	 Draw the best fit line through the data points. Extend the best fit line to find the vertical intercept. height at 0 °C, h_0 = 16.2 cm (accept 16.2 cm ≤ h_0 ≤16.4 cm)	B1
9(a)(iii) 1.	Internal energy of water is the **total energy of all the water molecules**. **It consists of the internal kinetic energy** due to the motion of the	B1

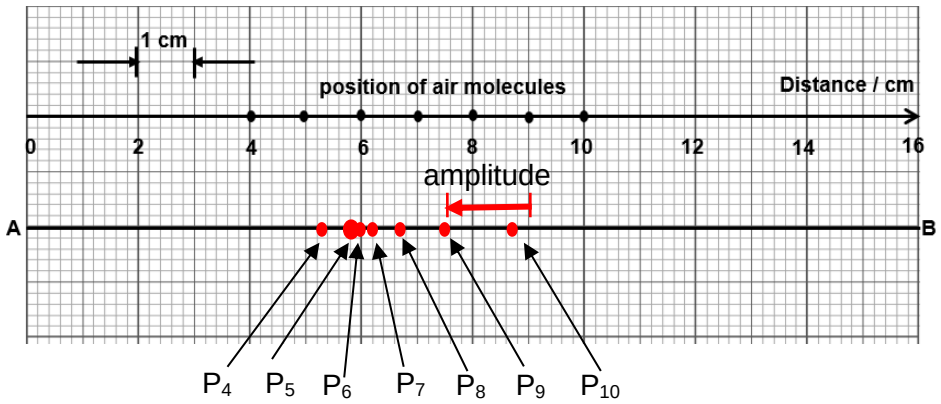
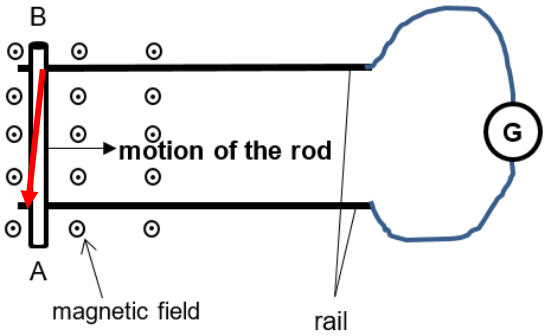
	water molecules **and the internal potential energy** due to the separation (or intermolecular bonds) between the water molecules. Or Internal energy of water is the **sum of the internal kinetic energy and the internal potential energy of the water**. Or Internal energy of water is **the sum of the kinetic energy and the potential energy of all the water molecules**.	
9(a)(iii) 2.	The **internal kinetic energy of the water molecules at 80°C is higher than the internal kinetic energy of the water molecules at 30 °C** while **the internal potential energy of the water molecules are the same at the two temperatures** because the separation between the molecules remains the same (in the liquid state) at the two temperatures.	B1 B1
9(b)(i)	**Evaporation of water** through leaves (transpiration) creates a low water vapour pressure in the bore	B1
9(b)(ii)	$\Delta p = hg\rho$ $P_o - P_T = hg\rho$ $(101 - 7.8) \times 10^3 = h\ (10)(1000)$ $h = 9.32$ m  	M1 A1
9(c)	Evaporation rate will be higher; pressure difference will be greater Hence height increases OR Water density will be lower [M1] Hence height increases [A1]	M1 A1
10(a)	The speed of the ball **decreases at a decreasing rate (or decreases non-uniformly** with time).	B1

<table>
<tr><td>10(b)(i)</td><td> 

Each force must be labelled and drawn in the correct direction</td><td>B1
B1</td></tr>
<tr><td>10(b)(ii)</td><td>The gradient of the speed time graph gives the deceleration of the ball. The magnitude of the deceleration of the ball decreases with the decrease in the speed of the ball. This is due to the decrease in the net force on the ball which is due to the weight of the ball and the air resistance. Since the weight of the ball is constant, the decrease in the net force on the ball is due to the decrease in air resistance. Hence air resistance decreases with the decrease in the speed of the ball.</td><td>M1

A1</td></tr>
<tr><td>10(c)(i)</td><td><table>
<tr><th>time / s</th><th>speed / ms^{-1}</th><th>magnitude of acceleration / ms^{-2}</th><th>direction of acceleration</th></tr>
<tr><td>1.0</td><td>8.0</td><td>13</td><td>down</td></tr>
<tr><td>1.75</td><td>0</td><td>10</td><td>down</td></tr>
</table></td><td>A2
[≥2 correct items 1 mark]</td></tr>
<tr><td>10(c)(ii)</td><td>Using F = ma

weight of the ball + air resistance = ma
(600 x 10^{-3})(10) + air resistance = (600 x 10^{-3}) (13)
air resistance = 1.8 N</td><td>C1
A1</td></tr>
<tr><td>10(d)</td><td>For the same distance travelled, the average speed downwards is smaller than the average speed upwards (since air resistance acts throughout the entire up and down motion),
hence the time taken to return to ground from the maximum height is longer than 1.75 s.</td><td>B1
(answer with reason)</td></tr>
<tr><td>EITHER
11(a)(i)</td><td>Radio waves are able to go around obstructions due to their longer wavelengths.</td><td>B1</td></tr>
</table>

EITHER 11(a)(ii)	Microwaves	B1
EITHER 11(a)(iii)	Advantage: **Microwaves is able to penetrate clouds and haze** (unlike light which will be reflected). Disadvantage: **Microwaves are highly directional** and **would be blocked by any obstruction** that lies between the transmitting satellite and the receiving satellite dish.	B1 B1
EITHER 11(b)(i) 1. 2.		B2 [subtract 1 mark for any wrong displacement] B1 [amplitude shown for particle P_9]
EITHER 11(b)(ii)	The air **molecules vibrate** in the **direction parallel** to the **direction in which the wave travels.**	A1
EITHER 11(b)(iii)	Wavelength λ = distance between particles 0 and 12 (in Fig. 11.2) = **12 cm** or = **0.12 m** Frequency = v/λ= 330/0.12 = **2750 Hz**	 A1 A1
OR 11(a)(i)	As **rod AB cuts across the magnetic field**, there is **a change of magnetic flux linking the circuit** and this produces an induced e.m.f.	B1 B1
11(a)(ii) 1		B1 (Direction)

11(a)(ii) 2	From Lenz's law, the **induced current will flow in a direction to oppose the motion producing it**. **Applying Fleming's left-hand rule**, **with the magnetic force exerted on rod AB towards the left and the magnetic field directed upwards**, the induced current will flow from B towards A. Alternative answer: **Applying Fleming's right-hand rule on <u>rod AB</u>**, the **thumb which indicates the motion of rod AB points to the right and the fore finger indicating magnetic field points upwards, the middle finger which indicates the induced current** points towards the end A of the rod.	B1 B1 B1 (RH rule on rod) B1 (describe method)
OR 11(b)(i)	primary coil = **M** (1 500 turns) secondary coil = **K** (100 turns) Step down ratio of voltages required (coil M : coil K) V_P / V_S = 3300 : 220 = 15 :1 Hence step-down ratio of turns (M:K) required N_P / N_S = 1500 : 100 = 15 : 1 Both ratio are the same or V_P/ V_S = N_P/ N_S	A1 M1 (working/ explanation)
OR 11(b)(ii)	$\frac{power\ output}{power\ input} = \frac{75}{100}$ Power input = $\frac{100}{75} \times 15\ kW$ = 20 kW Current flow through the primary coil, $I = \frac{P}{V}$ $= \frac{20\,000}{3300}$ = 6.1 A	C1 A1
11(b)(iii)	Use **<u>thick coils</u> to reduce the resistance** in both primary and secondary coils. Or **<u>Laminate</u>** the **soft iron core** to reduce energy lost as heat in the iron core. Both steps above will <u>reduce power lost as heat</u> generated in the coils or the soft iron core.	B1