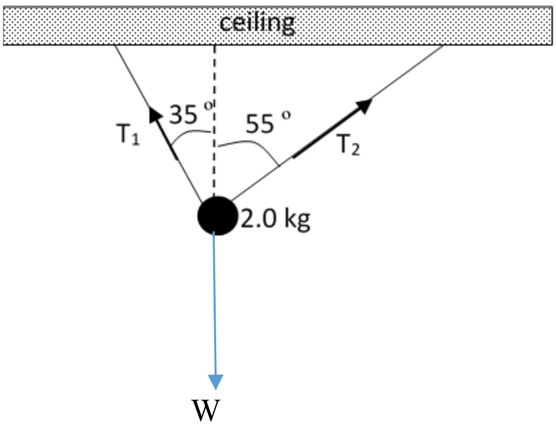
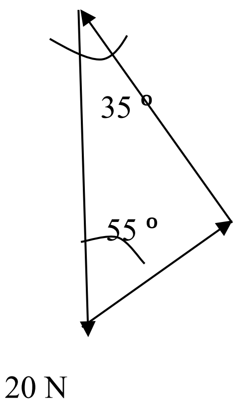
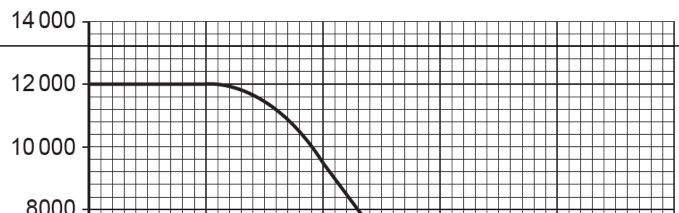
NAN CHIAU HIGH SCHOOL
Sec 4 Express Physics Papers 1, 2 and 3 Solutions
2022 Preliminary Examination

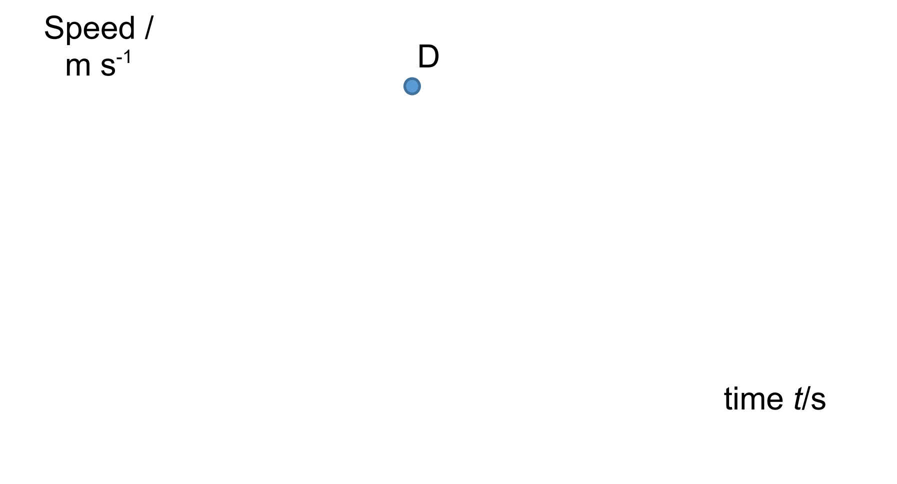
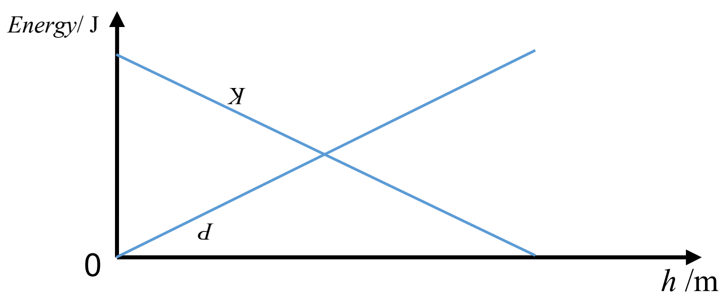
Paper 1 (40 marks)

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

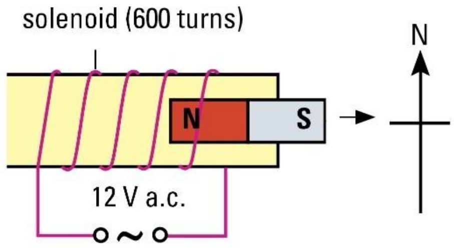
Paper 2 Section A (50 marks)

Question		Answer	Remarks
1	a	> The ball is at equilibrium as > it is at rest, no resultant moment/ no resultant forces / stationary / not moving.	B1 B1
	b	W = m.g = (2.0).(10) = 20 N (2sf)	
	c		The force must be from the centre of the ball and pointing downwards.
	d	 1 cm = 1.0 N T_1 = 16.4 N T_2 = 11.5 N	Deduct 1 mark each for: - No, wrong arrows; - Out of range; - Diagram too small,(minimum 1cm:2N - Wrong orientation *2 or 3sf is accepted
2	a		D should be between 12 to 18 secs

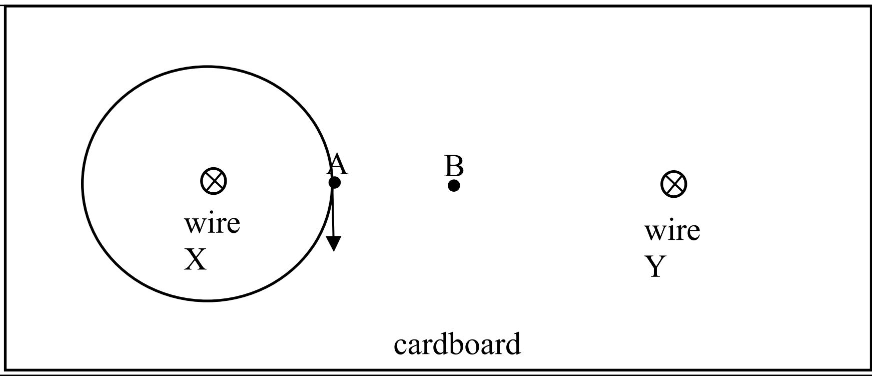


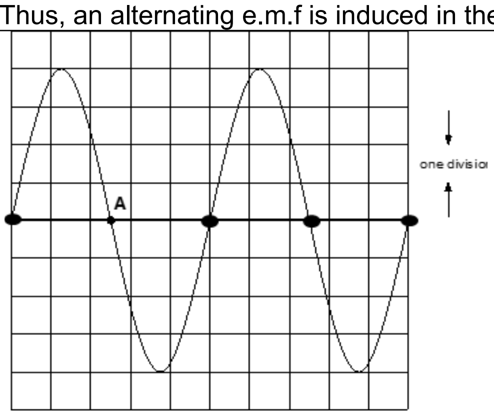
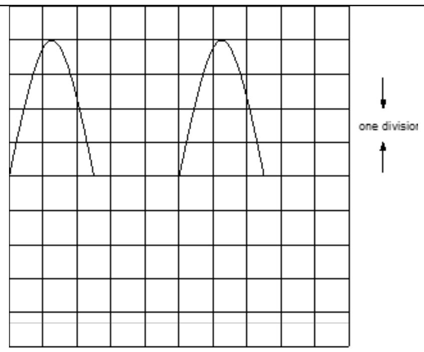
			
	b	(23, 8000), (31, 4000) acceleration = change of speed / time taken = (4000 – 8000) / (31- 23) = - 500 mm s^{-2} = -0.50 m s^{-2}. Deceleration = 0.50 m s^{-2} allowance for error 0.48 to 0.52 m s^{-2}	M1 A1
	c	> The rock is likely to have hit the bottom of the pond as > its speed changes from 2.0 m s^{-2} to 0 in an extremely short time, speed is zero, not moving (etc of the same meaning)	B1 (position) B1 (motion)
3	a	When an object is at <u>equilibrium</u>, the <u>sum of clockwise moments about any point equal to the sum of anti-clockwise moments about the same point.</u>	B1 B1
	b	Sum of anti-clockwise moments = sum of clockwise moments $90.R_B = (40).(25) + (90\text{-}80).(600)$ $R_B = 77.77$ N = 78 N (2 sf)	 M1 A1
	c	The position of the centre of gravity of the man-ladder system will <u>rise</u> and the system to be <u>less stable</u>. *do not accept “CG increase” , as a position cannot increase. reasoning of system to be less stable must be correct also.	M1 A1
4	a	The force per unit mass acting on an object under gravity.	
	bi and bii		1m for both shapes correct 1m for both labels P and K correct 1m for total energy is constant
	c	GPE at 40 m = m.g.h = (5.0).(10).(40) = 2000 J GPE at 40 km = m.g.h = (5.0).(9.7).(40 000) = 1,940,000 J Difference in GPE = 1,940,000 – 2000 = 1,938,000 = 1,900,000 J (2 sf)	(both gpe must be correct to get 1m) 1m
5	a	$(h.\rho.g)_{air} + (h.\rho.g)_{H\ \text{at position P}} = (h.\rho.g)_{Hg\ \text{at foot of mountain}}$ $h_{air}.(1.23).(10) = (0.760 - 0.700).(13600).(10)$ $h_{air} = 663$ m (No marks will be awarded if students only state pressure difference as 6.0 cm Hg)	M1 M1 A1
	b	As point P has a <u>lower atmospheric pressure</u> than at sea level, the molecules <u>do not need to overcome so high downward force exerted by the atmospheric pressure</u> than when it is at sea level, so less energy is needed to boil water a point P, so water boils at a lower temperature.	1m 1m

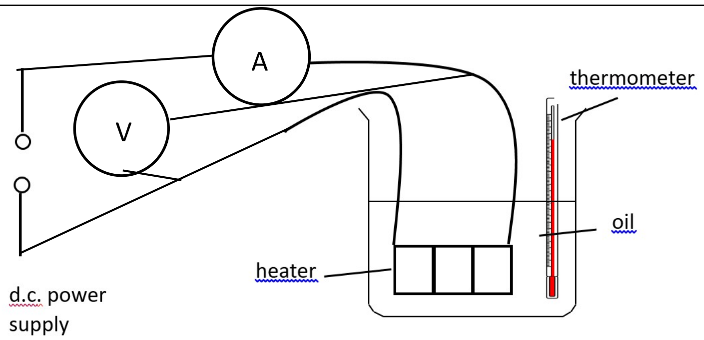
		Note: energy required to overcome intermolecular forces of attractions at P and at the foot of the mountain is constant thus the assumption by most students that less energy is required to overcome the intermolecular forces of attraction at P is incorrect.	
6		➢ The marker is too thick, thinner markers should be used. ➢ Should divide the length into 100 equal divisions of 1 °C, not 8 divisions. ➢ Should use boiling point of water instead of 80 °C as it is not easy to reproduce exactly 80 °C. ➢ Ice point was marked after only 10 s which is too fast, should mark after at least 2 min for the reading to be stabilised. ➢ Placing the thermometer above the boiling water/in the steam and not inside the hot water. Do not accept : > use pure ice as 0 deg C is stated in the question > use equal mass/volume for 0 deg C ice/water and for 80 deg C water as it does not affect the temperature > repeating the experiment is not an improvement as there is no change to the setup > Any methods to reduce heat loss such as insulation is irrelevant.	1 m for each point, max 3 marks
7	**a**	It is a process of charging a conductor without contact between the charging body and the conductor.	
	b	The electrons (BOD: negative charges) inside insulators cannot move even in an electric field, so they cannot be charged by induction. OR Insulators have no mobile electrons.	
	c	➢ Bring Plate X near to (BOD: close together) but not touching Plate Y, connect the earth wire to Plate Y. (Accept "connect earth wire first, then bring X near") ➢ Disconnect the earth wire and bring Plate X far far way from Plate Y.	1 m 1 m
8	**a**	➢ The resistor is ohmic as ➢ its I-V graph is a straight line passing through the origin or Current is directly proportional to voltage or Resistance is constant. ➢ The lamp is not ohmic as ➢ its I-V graph is not a straight line or Current is not directly proportional to voltage or Resistance is increasing.	Minus 1 m for each wrong/ missing part Max minus 3 m
	b	From Fig. 8.1, the resistances of the lamp and of the resistor are equal (where the I-V graphs intercept) when the lamp has pd of 7.0 V (2 sf) and current of 4.6 A	
	C	➢ From Fig. 8.1, when the total pd is 7.6 V and when current is the same for lamp and resistor, current of lamp is 3.0 A and pd across the lamp is 3.0 V. ➢ Resistance of lamp = 3.0 V / 3.0 A = 1.0 Ω.	
9	**a**	➢ It can be attracted by magnets. ➢ It can be made to be magnets (or be magnetised).	1 m 1 m
	bi	Steel/ Cobalt/ Lodestone/ Nickel	
	bii	As the iron bar is placed near the permanent magnet, its right-hand side is induced a South pole and left-hand side a North pole. As unlike poles attract and like poles repel, the attractive forces between the North pole of the permanent magnet and the South pole of the induced magnet is stronger than the repulsive force between the North-pole of the permanent magnet and North-pole of the induced magnet as the distance between the unlike poles are smaller, so there is a net attractive force.	

	c	 ➢ Place a magnet inside a solenoid connected to an alternating current (a.c.) supply ➢ Without switching off the current, withdraw the magnet slowly in the East-West direction.	1 m for correct diagram 1 m 1 m

Paper 2 Section B (30 marks)			
10	ai	When the heater is placed at the bottom, it heats up the liquid at the bottom. The liquid expands and becomes less dense, it then rises to the top. The colder, denser liquid sinks to the bottom. This creates a convection current in the liquid and will ensure the heat is distributed evenly.	
	aii	I.V.t = C.Δθ C = (I.V.t) / Δθ = (5.0).(20).(12).(60) / (38 – 30) = 9000 J / °C	M1 A1 Deduct 1 mark if uses min or hour for time
	aiii	➢ Yes, the student is right. ➢ From 26 °C to 30 °C (room temperature), the liquid gain heat from the surrounding and from 30 °C to 34 °C, the liquid lose heat to the surrounding. ➢ The heat gained and loss from and to the surrounding can potentially cancelled off and the heat capacity calculate will be more accurate.	Max 2 marks No mark if stated yes but with wrong reasons.
	bi	➢ Real ➢ Diminished ➢ Inverted	1 m for 2 correct, 2 m for 3 correct.
	bii	➢ f = 10 mm. ➢ When object distance is 20 mm, image distance is also 20 mm, this means that the object size is equal to the image size, which means the object is placed at 2f from lens. So since 2f = 20 mm, f = 10 mm. ➢ 1/f = 1/u + 1/v 1/f = 1/30 + 1/15 f = 10 mm	
11	ai	➢ Type I : ultraviolet radiation ➢ Type II : visible light ➢ Type III : infrared radiation	1 m for 2 correct, 2 m for 3 correct
	Aii	All the brands can be used in vacuum as all electromagnetic waves can travel in vacuum.	

	bi	I_{CE} (through LDR and 20 Ω resistor) = V / R = 12 / (20 + 180) = 0.060 A I_{CE} (through lamp and 60 Ω resistor) = 0.66 – 0.060 = 0.60 A $I_{60\Omega}$ = V / R = 12 / 60 = 0.20 A Therefore I_{lamp} =0.60 – 0.20 = 0.40 A R_{lamp} = 12 / I_{lamp} = 12 / 0.40 = 30 Ω *Alternatively,* $V/I = [1/(20 + R_{LDR}) + 1/60 + 1/R_{lamp}]^{-1}$ $12/0.66 = [1/(20+180] + 1/60 + 1/R_{lamp}]^{-1}$ $18.18 = [0.00500 + 0.0167 + 1/R_{lamp}]^{-1}$ $0.055 = 0.0217 + 1/R_{lamp}$ $0.0333 = 1/R_{lamp}$ R_{lamp} = 30 Ω	 B1 B2 A1 Deduct 1 m for each mistake
	bii1	No change in the brightness of the lamp as both potential difference and resistance of the lamp remains unchanged so power of lamp remains unchanged too.	
	bii2	The current measured by the ammeter decrease.	
12 Either	**ai**		
	aii	> There is no magnetic field at point B > because the magnetic field due to wire X at point B is downwards and the magnetic field due to wire Y at point B is upwards. Since point B is at the midpoint of wires X and Y and both X and Y carry the same amount of current, there is no magnetic field at point B	Need to mention either equal magnitude of magnetic field strength/equal current or mention direction of magnetic field strength due to wire X and wire Y to get the second mark
	aiii	Upwards Do not accept “clockwise” as it can be either upwards or downwards.	
	bi	Magnet : to provide magnetic field Carbon brush : to make contact between the slip rings and the external circuit.	

		(Do not accept "to conduct electricity")	
	bii	From Fleming Left-hand Rule, the right-hand side of the coil experiences a downward force and the left-hand side an upward force. >The split-ring commutator reverses the direction of the current in the coil every half a revolution. >When the coil is at the vertical orientation, there is no current flowing in the coil, however, the inertia causes the coil to continue to turn clockwise, >once the coil crosses the vertical orientation, the force acting the right-hand side of the coil will be downward and left-hand side upwards, so the coil can turn clockwise continuously.	
12 Or	**ai**	➢ Based on Faraday's Law of Electromagnetic Induction, when the magnet rotates, the changing magnetic flux through the soft iron core causes a change in magnetic flux linking the coil, an e.m.f is induced across the coil. ➢ As the N-pole of the magnet approaches the left arm of the soft iron, by Lenz' Law, the induced current in the coil will produce a magnetic field to oppose the change in magnetic flux, thus the left of the coil will be a North pole, likewise, as the N-pole of the magnet moves away from A, based on Lenz's Law, the induced current in the coil will generate a magnetic field with a South pole at the left of coil. Thus, an alternating e.m.f is induced in the coil.	
	ai & aii		correct peak voltage : 1 m; correct period : 1 m; Deduct 1 m for wrong shape. "A" can be any point on the graph when the induced emf is 0.
	aiii		Shape : 1 m Period and amplitude : 1 m. ecf from aii for wrong amplitude, wrong period or wrong shape
	bi	Step-up transformer	
	bii	> Copper loss : use shorter, thicker wires OR >Magnetic flux leakage : use soft iron core to have better flux linkage OR >Loss due to Eddy current : use laminated iron core instead of one thick iron core OR > Hysteresis loss : reduce input source frequency.	

Answer key for NCHS Prelim 2022 P3		
Help rendered to set-up : Q1 : deduct 2 marks, Q2 : deduct 1 mark, Q3 : deduct 3 marks. **Marks deduction rule for sf/dp and unit errors:** **Deduct maximum 1 m for dp/sf error and another maximum 1 m for unit error or no unit within the SAME PART OF A QUESTION, for eg, Q1c, Q2b, Q3a.**		
1a	 Ammeter and voltmeter in series [0] Ammeter connected such that heater can heat up but voltmeter connected wrongly [1] Ammeter in series to heater and voltmeter in parallel to heater [2]	[2]
1b	$\theta_i =$ .... (1 d.p)	
1c	I = 0.81 A (2 d.p) *[All readings must be in increment of 0.01, at least 0.70 A.]* V = 3.80 V (2 d.p) *[All readings must be in increment of 0.05, at least 3.00 V.]* *- V = 3.84 V is not acceptable [not increment of 0.05]* *- Deduct 1m if V is too low*	[2]
1d	$\theta_f =$ .... (1 d.p)	
1e	E = VIt = 3.80 x 0.81 x 5 x 60 = 923.4 J = 920 J (1 or 2 sf)	[2]
1f	Heat Capacity, C = Q/Δθ = 920/(40.0 - 30.0) = 92 J/ ºC or 92 J/K (follow sf from 1e)	[2]
1g	any 2 sensible suggestions e.g. B2 - oil not lagged / heat loss (to air) - battery becomes weaker during heating causing voltmeter and ammeter readings to drop - resistance of the copper wires get hot and resistance increases causing the voltmeter and ammeter readings to decrease as the experiment progresses - BOD - voltmeter and ammeter readings change/drop - BOD - thermometer gains heat directly from the heater/resistor instead of the oil - BOD - Contact resistance due to crocodile clips not having a firm grip with the resistance wire *Do not accept :* - *oil is not pure (we are not boiling it nor measuring its boiling point so it doesn't matter)* - *parallax errors when reading thermometer, ammeter or voltmeter* - *oil is not exactly 0.035 kg as this value is NOT used in the calculation of heat capacity C* - *evaporation of oil (cooking oil takes months to years to evaporate, and the boiling point of cooking oil is almost 200 deg C)* - *experiment is only done once, so not accurate, need to repeat experiment* - *Human Reaction Time Error in starting and stopping the stopwatch, very small compared to 5 minutes* - *thermometer touching the beaker (as the temperature of beaker and oil is about the same)*	[2]\

<table>
<tr><td></td><td>- time needed for thermometer reading to reach the highest/take some time to reach the highest (stated in the question)
- bulb not submerged fully in the oil (it is a precaution)</td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>2bi</td><td>Correct u_1 and v_1 [length in 1 d.p]
u_1 > 30.0 cm, v_1 from 15.0 to 30.0 cm</td><td>[1]</td></tr>
<tr><td>2bii</td><td>Correct u_2 and v_2 [length in 1 d.p]
u_2 from 15.0 to 30.0 cm, v_2 > 30.0 cm</td><td>[1]</td></tr>
<tr><td>2c</td><td>Correct f = 15.0 cm (+/- 1.0), 3sf</td><td>[1]</td></tr>
<tr><td>2d</td><td>● move screen slowly / to and fro until sharpest focus obtained
● repeat each reading and average
● object / lens / screen perpendicular to bench
● object and lens same height above the bench
● carry out experiment away from other bright light sources darkened room
● take reading perpendicular to scale or ruler / avoidance of parallax described
● screen, lens and light source parallel to one another
● lens in the centre of lens holder</td><td>[1]</td></tr>
<tr><td rowspan="6">2e</td><td>To investigate how u affects v or how 1/u affects 1/v.

IV: 1/u [accept u]
DV: 1/v [accept v]
CV1: ensure that object and lens are same height
CV2: ensure object/screen/lens must be perpendicular to the bench</td><td>[1]</td></tr>
<tr><td>Describe how to take 1 reading using u = 0.100 m.
Setup the experiment in Fig. 2.1 with u = 0.100 m.
Record the value of v once a sharp image is observed.</td><td>[1]</td></tr>
<tr><td>Repeat 5 more times with u = 0.200 m, 0.300 m, 0.400 m, 0.500 m, 0.600 m.

Repeat all 6 readings again to find the average v for each u. (optional)</td><td>[1]</td></tr>
<tr><td><table><tr><td>u/m</td><td>v/m</td><td>1/u /m^{-1}</td><td>1/v/ m^{-1}</td></tr><tr><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td></tr></table>
need all the 4 columns, ignore units.

6 empty rows can replace “repeat 5 more rows” in the previous mark.

Min 1 header row to score this table mark.</td><td>[1]</td></tr>
<tr><td>1/v is linearly related to 1/u.

“negative gradient” can be implied by the sketch of graph.

Plot 1/v vs 1/u [ecf of plot v against u]</td><td>[1]</td></tr>
<tr><td>The y-intercept = 1/f,</td><td>[1]</td></tr>
</table>

<table>
<tr><td></td><td>so f = 1/y-intercept.</td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>3ai</td><td>R = <u>1.0 or 1</u> Ω</td><td></td></tr>
<tr><td></td><td>Y = <u>0.650 - 0.760</u> m
[if candidate put 70.7, deduct 1 mark for unit]
[if 0 metre means student connect wrongly]</td><td>[1]</td></tr>
<tr><td>3aii</td><td>
<table>
<tr><td>R/ Ω</td><td>y/m</td><td>(1/y)/m^{-1}</td></tr>
<tr><td>1 or 1.0</td><td>0.707</td><td>1.41</td></tr>
<tr><td>2 or 2.0</td><td>0.615</td><td>1.62</td></tr>
<tr><td>3 or 3.0</td><td>0.565</td><td>1.77</td></tr>
<tr><td>5 or 5.0</td><td>0.495</td><td>2.02</td></tr>
<tr><td>7 or 7.0</td><td>0.440</td><td>2.27</td></tr>
<tr><td>10 or 10.0</td><td>0.370</td><td>2.70</td></tr>
</table>

[R can be 0 dp or 1 dp]
H/U [1] - 1/y / m^{-1} can be interpreted from graph ,
dp/sf [1] - 1/y / m^{-1} column must be there
y/m trend - decreasing [1]
6 data min (allow 2 error in plotting) [1] (allow only 1 outlier)</td><td>[4]</td></tr>
<tr><td>3bi</td><td>Plot a graph of 1/y against R

● axis (labelling of axis with units, correct dp on both axis, ECF from table)
● scale (first and last data to occupy at least 50% of both axes, no odd scale)
● points correctly plotted
any missing input deduct 1m.
need two correct inputs to get at least 1m.

Check 2 random points if correct stop checking
If 2 wrong points deduct 1m
If 1 wrong point, need to check all remaining points

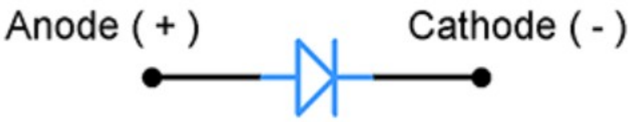
● BFL (penalise for curve line here)</td><td>[4]</td></tr>
<tr><td>3bii</td><td>● Triangle or Coordinates [ignore even if candidate fail to read to ½ the smallest square]

gradient = (2.60-1.34)/(9.4-0.0)=0.134
[no unit required, penalise if candidate gives wrong unit]
accept 2 or 3 sf
Gradient must be between 0.114 to 0.154</td><td>[1]

[1]</td></tr>
<tr><td></td><td>y-intercept = 1.34 [no unit required, penalise if candidate gives wrong unit]
Y-intercept must be between 1.14 to 1.54

candidates read to their graph (can be 1 or ½ small sq)

if candidates calculate by linear law, 2 or 3 sf.</td><td>[1]</td></tr>
<tr><td>3biii</td><td>1/y is linearly related to R.</td><td></td></tr>
<tr><td>3c</td><td>Equation 1/y = 1+ Q/P + R/P</td><td></td></tr>
<tr><td></td><td>1/P= gradient value from graph in cii, P = …7.50 Ω……
[unit is not required, 2 or 3 sf]</td><td>[1]</td></tr>
<tr><td></td><td>y-intercept is 1 + Q/P = 1.34, Q = …2.55 Ω ……. [unit is not required, 2 or 3 sf]</td><td>[1]</td></tr>
</table>

3d		[1]
3e	Length of y = (0.20 V/3.00 V) * 1.00 m = 0.067 m or 6.7 cm. *[candidates NEED to use the potential divider concept to get the value of y. It is wrong to use the equation of Q3c which is 1/y = 1+ Q/P + R/P to calculate y because resistor P is no longer there.]*	[2]
3f	There are kinks on the wire, thus the length of the wire from A to B or B to C is actually longer than the actual length, this results in a higher potential reading at B. The switch may be switched on throughout the entire experiment leading to higher resistance in the wire due to the heating effect of the current.	[1]
3g	HIGHER Potential @ B remains the same Potential @ D decrease to 0V as it is the same potential as C and at the negative terminal.	[1]