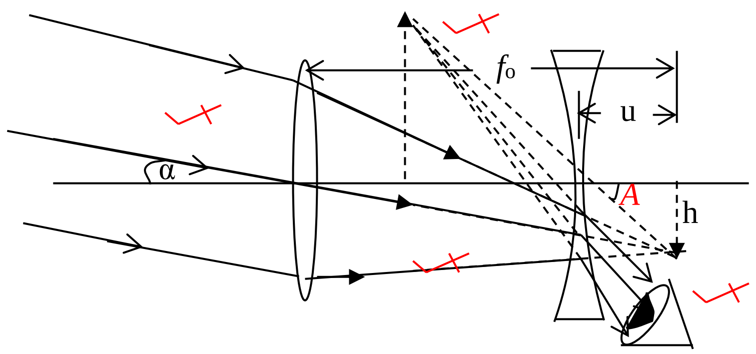
<table>
<tr><th>Qn</th><th>Answer</th><th>Marks</th></tr>
<tr><td>1. (a)</td><td>(i) Resolving power means the smallest angular separation that can unambiguously be distinguished by an optical system.</td><td>1</td></tr>
<tr><td></td><td>(ii) …the ratio of the angle subtended by the image at the aided eye to the image subtended by the object at a naked eye.</td><td>1</td></tr>
<tr><td>(b)</td><td>(i)
- No chromatic aberration
- Image is brighter than for refractor type
- One surface only has to be ground
- Greater resolving power
Any two @1</td><td>2</td></tr>
<tr><td></td><td>(ii) … by cutting off the marginal rays.</td><td>1</td></tr>
<tr><td></td><td>(iii)



Rays from a point on a distant object arrive at the objective lens as a parallel beam.
The objective converges the rays to its focal plane and forms an intermediate image there, which then acts as the object for the eyepiece.
$\alpha = h/f_o$ and $\alpha' = h/u$
Using $1/v + 1/u = 1/f$ we have
$-1/f_e = 1/-D + 1/u$ (eyepieces is diverging)
Therefore $u = \dfrac{f_e D}{f_e - D}$
Now magnification, $M = \dfrac{\alpha'}{\alpha} = \dfrac{h/u}{h/f_o} = \dfrac{f_o}{u}$
Therefore $M = \dfrac{f_o}{f_e}\dfrac{(f_e - D)}{D}$
∴ $\mathbf{M = \dfrac{f_o}{f_e}\left(\dfrac{f_e}{D} - 1\right)}$</td><td>½
½
½
½

1
1

1

1

1</td></tr>
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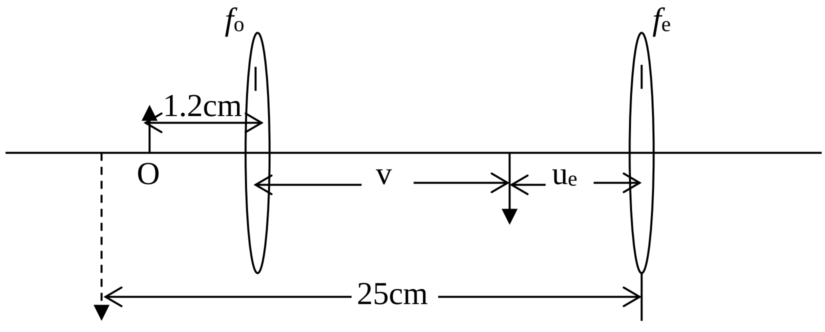
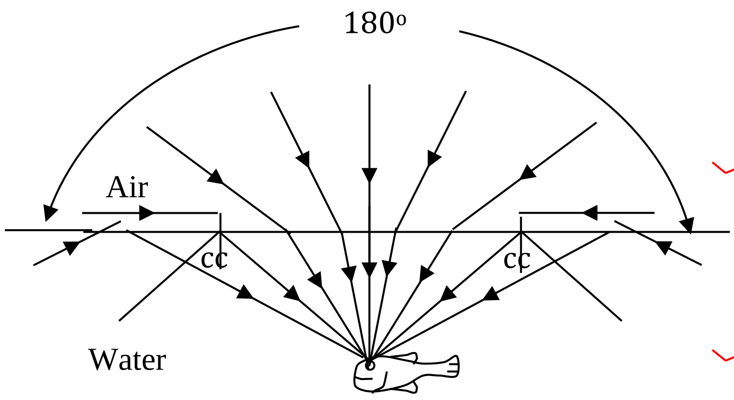
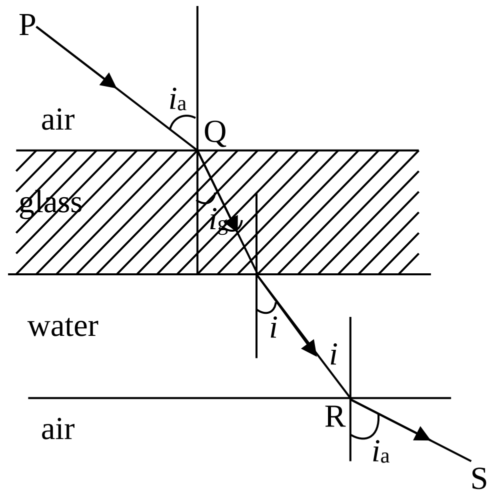
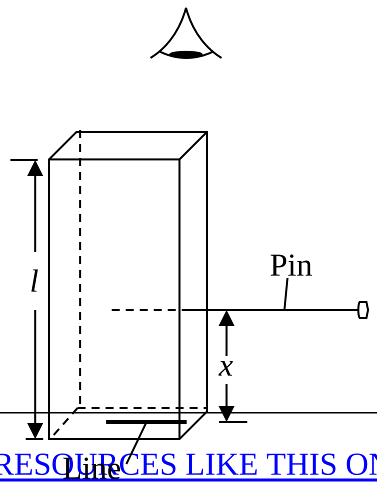
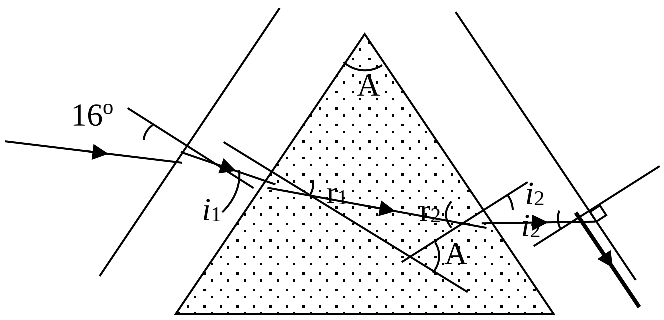
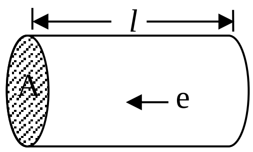
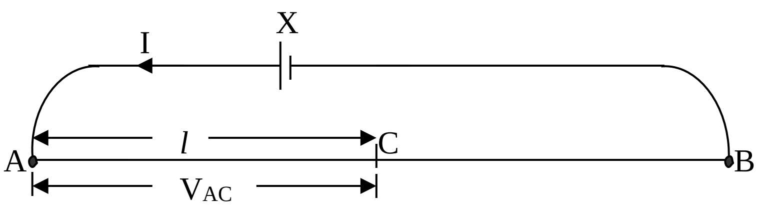
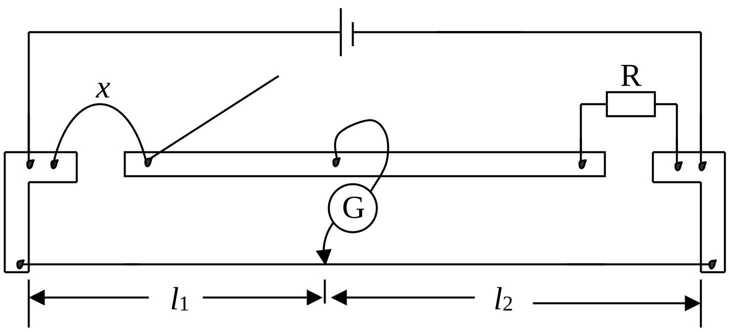
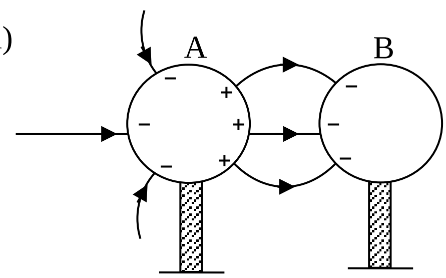
(c)	(i) 	
	Using $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$ we have $v = \frac{uf}{u-f} = \frac{1.2\times 1}{1.2-1} = 6.0$ cm	1
	and $u_e = \frac{f_e D}{D-f_e} = \frac{10\times(-25)}{-25-10} = 7.1$ cm	1
	$\therefore$ distance between the lenses = $v + u_e$ 6.0 + 7.1 = **13.1 cm**	1
	(ii) $M = -\left(\frac{D}{f_e}+1\right)\left(\frac{v}{f_o}-1\right)$	2
	$= -\left(\frac{25}{10}+1\right)\left(\frac{6}{1}-1\right)$	1
	= -3.5 x 5 = -17.5	1
Total = 20		
2. (a)	(i) – The incident ray must be travelling from a denser medium to a less dense one.	1
	- The angle of incidence (in the denser medium) must be greater than the critical angle	1
	(ii) Optical fibre Binoculars Periscope } *A diagram of any one of these*	2
(b)		1 1

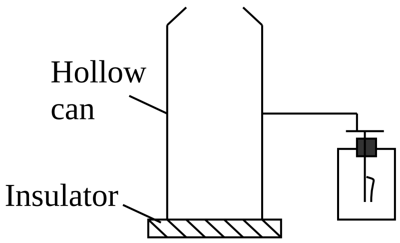
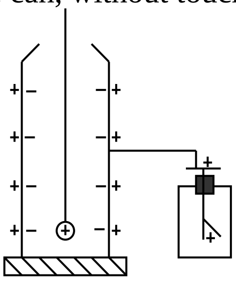
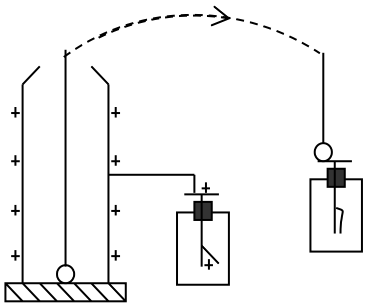
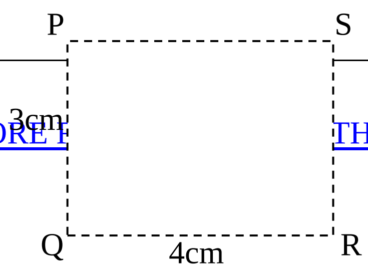
	If the water surface is calm, all the rays of light striking it are refracted in such a way that the fish's eye can receive light from anywhere above the water surface.	1
(c)	Consider a ray PQ incident in air on a plane glass boundary and finally emerging along a direction RS in air.  If the boundaries of the media are parallel, RS is parallel to PQ. Let i_a,i_g, i_w respectively be the angles made with the normals in glass and water media. Then, looking at the upper side, $\sin i_a = {}_an_g \sin i_g$………………. (1) and at the lower side $\sin i_a = {}_an_w \sin i_w$ ………………. (2) from (1) and (2) $\sin i_a = {}_an_g \sin i_g = {}_an_w \sin i_w$ Since $n_a = 1$, it follows that ${}_an_g = n_g$ and ${}_an_w = n_w$ So we can write $n_a \sin i_a = {}_an_g \sin i_g = {}_an_w \sin i_w$ $\therefore$ **n sin *i* = constant**	½ 1 1 ½ ½ ½
(d)		1

	- The length, *l*, of the longest edge of the glass block is measured and noted. - A clear line is drawn on a white sheet of paper. - The glass block is placed on the line, with its longest edge vertical. - While observing the image of the line from above, a horizontal pin is moved along the side of the block to a position where it coincides with the image of the line. - Then, the height, *x*, of the pin above the line is measured. Now, the apparent height of the block is $l - x$. So, the refractive index $= \frac{l}{l-x}$	½ ½ ½ ½ ½ ½
(e)	 Let n_g = refractive index of glass Then $\sin 16^o = n_g \sin i_1$ ………….. (1) and $1.33 \sin r_1 = n_g \sin i_1$ ………….. (2) From (1) and (2) $1.33 \sin r_1 = \sin 16^o$ $\therefore \sin r_1 = \frac{\sin 16^o}{1.33} = 0.207$ $\therefore r_1 = 11.9^o$ Also $1.33 \sin r_2 = n_g \sin i_2$ ………….. (3) and $\sin 90^o = n_g \sin i_2$ ………….. (4) From (3) and (4): $1.33 \sin r_2 = \sin 90^o$ $\therefore \sin r_2 = \frac{1}{1.33} = 0.752$ $\therefore r_2 = 48.8^o$ Now, $A = r_1 + r_2 = 11.9 + 48.8 =$ **60.7°**	½ ½ ½ ½ ½ ½ ½ ½ 1
	Total = 20	
3. (a)	(i) … at constant temperature, the current flowing through a wire is directly proportional to the potential difference between the ends of the wire and the relationship is independent of the direction of current or potential difference.	1

	(ii) - Length - Cross-sectional area - Temperature - Material of the wire	 ½ ½ ½ ½
	(iii)  Number of electrons in the piece of wire $= nlA$ So the charge ready to flow in the wire is $nlAe$ If in time t all these electrons flow past section A, then the current flowing is $I = \frac{nlAe}{t}$ Now, $v = \frac{l}{t}$ $\therefore \quad v = \frac{I}{nAe}$	 ½ ½ 1 1 1
(b)	 A potentiometer consists of a uniform wire AB through which a steady current, I, is maintained by a steady source X. Since the wire is uniform, its resistance per cm, say ρ, is constant. Measurements on this instrument are made by balancing a p.d in the circuit under test against a p.d V_{AC}, portioned by a sliding contact, between one end A and some point C along wire AB. Thus the p.d being measured = p.d V_{AC} But $V_{AC} = I\rho l$ $V_{AC} \propto l$ Thus in potentiometer experiments lengths are measured.	1 ½ ½ ½ ½ ½ ½
(c)	(i) The p.d. $V_{AB} = \frac{R_{AB}}{R_{AB}+1}\times 2 = \frac{4}{4+1}\times 2 = 1.6$ V When S is open, it is the emf of X that is being balanced So $E_x = \frac{88.75}{100}\times 1.6$ $= \mathbf{1.42\ V}$	1 1 1

	(ii) When S is closed, the terminal p.d. $V = \frac{8}{8+r} \times E_x \Rightarrow \frac{E_x}{V} = \frac{8+r}{8}$ This gives a balance length of 81.55 cm $\therefore \quad \frac{8+r}{8} = \frac{88.75}{81.55}$ $\therefore \quad r = 8 \times \left(\frac{88.75}{81.55} - 1\right)$ $= \mathbf{0.706\ \Omega}$	1 1 1 1
(d)	- At balance no current is drawn from the circuit under test, which ensures accuracy during p.d. measurements. - Its accuracy can be increased by using a longer potentiometer wire	1 1
	Total = 20	
4. (a)	(i) … the resistance per unit length of a material of unit cross-sectional area. The unit of resistivity is **Ωm**	1 1
	(ii)  - A length x of the wire is connected in one gap of the metre bridge while a standard resistor, R, is connected in the other gap and so chosen as to bring the balance points in the middle third during the experiment. - The circuit is connected as shown, and the balance point is found. Balance lengths l_1 and l_2 are noted. - The experiment is repeated for several different lengths x, each time noting the corresponding balance lengths l_1 and l_2. - A graph of $\frac{l_1}{l_2}$ against x is plotted - The diameter, d, of the wire is measured and noted. Let β = resistivity of the wire Then the resistance of the wire of length x is $R_x = \frac{4\beta x}{\pi d^2}$ Now $\frac{R_x}{R} = \frac{l_1}{l_2}$ $\therefore \quad \frac{l_1}{l_2} = \frac{4\beta}{\pi d^2 R} x$ So the slope of the graph, $s = \frac{4\beta}{\pi d^2 R}$ $\therefore \quad \beta = \frac{1}{4} \pi d^2 R s$	1 1 ½ 1 ½ ½ 1 ½

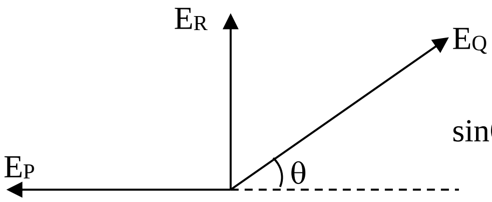
(b)	(i) This is because contacts at the ends of the bridge wire have resistances and these may not be negligible compared to the low resistances.	1 1
	(ii) Let e_1 and e_2 be the end errors From the first connection $\frac{4}{8} = \frac{32 + e_1}{68 + e_2} \Rightarrow e_2 = 2e_1 - 4$ ……… (1) From the second connection $\frac{8}{4} = \frac{69 + e_1}{31 + e_2}$ $\therefore$ $62 + 2e_2 = 69 + e_1$ ………………………… (2) Substituting for e_2 we have $3e_1 = 15$ $\therefore$ $e_1 = 5.0$ cm $\therefore$ corresponding end resistance, $r_1 = 5 \times 0.05 =$ **0.25 Ω** Substituting for e_1 in eq(1) we have $e_2 = 2 \times 5 - 4$ $= 6.0$ cm $\therefore$ corresponding end resistance, $r_2 = 6 \times 0.05 =$ **0.30 Ω**	1 1 1 1 1
(c)	$R_x = \rho\frac{l}{A} = \frac{0.6}{\frac{1}{4}\pi d^2}\rho = \frac{0.6 \times 4}{\pi \times (2 \times 10^{-5})^2}\rho = \frac{6}{\pi} \times 10^9 \rho$ Resistance in the left $= \frac{RR_x}{R + R_x}$ $\therefore \frac{RR_x}{(R + R_x)Q} = \frac{66.7}{33.3}$ $\therefore \frac{5R_x}{(5 + R_x) \times 2} = \frac{66.7}{33.3} = 2$ $\therefore$ $5R_x = (5 + R_x)4$ $\therefore$ $R_x = 20$ $\therefore \frac{6}{\pi} \times 10^9 \rho = 20$ $\therefore \rho = \frac{20}{6}\pi \times 10^{-9} =$ **1.05×10^{-8} Ωm**	1 1 1 ½ ½ 1
	Total = 20	
5. (a)	(i) and (ii)  -	2 2
(b)	(iii) As the spheres are moved apart, the p.d. rises.	1

	This is because the neutralising effect of the opposite charges on the spheres becomes smaller at a greater separation so that the magnitude of the electric potential of each sphere rises. Hence increased p.d.	1
	 - A hollow metallic can is placed on an insulator and connected to a neutral electroscope. - A metal ball, is suspended from a silk thread, given a positive charge and lowered into the can, without touching its walls.  The leaf is observed to diverge, and as long as the ball is inside the can no change of deflection occurs even when it is moved about within the can. - The ball is allowed to touch the inside  Still the deflection is unchanged. This shows that the outside did not lose or gain any charge. - Finally, the ball is removed. The deflection still remains unchanged, and when tested with another electroscope, the ball is found to have lost all the charge; also, the inside of the can has no charge.	½ 1 ½ 1 ½ ½ 1
(c)		

$E_P = \frac{Q_P}{4\pi r_P^2} = \frac{-3\times10^{-6}\times9\times10^{9}}{0.04^2} = 1.69\times10^{7}\ N\,C^{-1}$ horizontally to the left

$E_Q = \frac{Q_Q}{4\pi r_Q^2} = \frac{4\times10^{-6}\times9\times10^{9}}{0.05^2} = 1.44\times10^{7}\ N\,C^{-1}$ diagonally towards S — 1

$E_R = \frac{Q_R}{4\pi r_R^2} = \frac{3\times10^{-6}\times9\times10^{9}}{0.03^2} = 3.0\times10^{7}\ N\,C^{-1}$ vertically upwards — 1



1

$\sin\theta = 0.6$ and $\cos\theta = 0.8$

½

Let E_X = horizontal component of the resultant intensity
and E_Y = vertical component of the resultant intensity
Then $E_X = E_P - E_Q\cos\theta = (1.69 - 1.44\times0.8)\times10^{7}$ to the left $= 0.538\times10^{7}\ N\,C^{-1}$

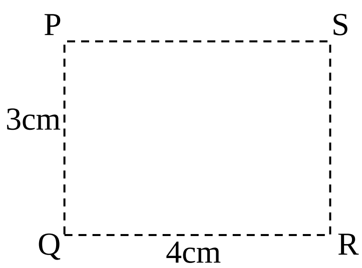
and $E_Y = E_R + E_Q\sin\theta = (3.0 + 1.44\times0.6)\times10^{7}$ upwards $= 3.864\times10^{7}\ N\,C^{-1}$ — ½

½

Resultant intensity $= \sqrt{E_X^2 + E_Y^2}$ — ½

$= \sqrt{0.538^2 + 3.864^2}\times10^{7} =$ **$3.9\times10^{7}\ N\,C^{-1}$** — 1

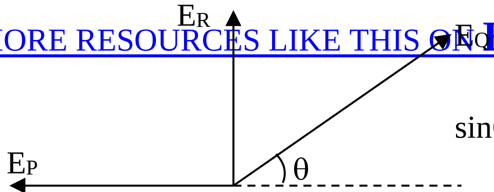
(d)



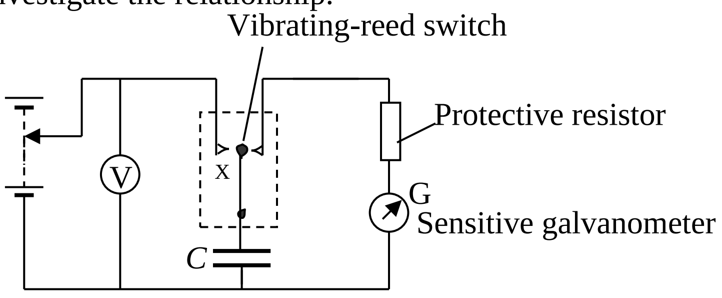
$E_P = \frac{Q_P}{4\pi r_P^2} = \frac{-3\times10^{-6}\times9\times10^{9}}{0.04^2} = 1.69\times10^{7}\ N\,C^{-1}$ horizontally to the left — 1

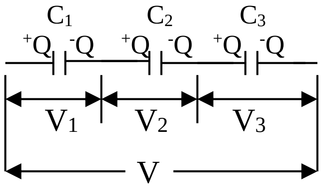
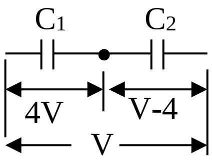
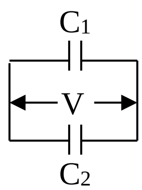
$E_Q = \frac{Q_Q}{4\pi r_Q^2} = \frac{4\times10^{-6}\times9\times10^{9}}{0.05^2} = 1.44\times10^{7}\ N\,C^{-1}$ diagonally towards S — 1

$E_R = \frac{Q_R}{4\pi r_R^2} = \frac{3\times10^{-6}\times9\times10^{9}}{0.03^2} = 3.0\times10^{7}\ N\,C^{-1}$ vertically upwards — 1



$\sin\theta = 0.6$ and $\cos\theta = 0.8$

		½
	Let E_X = horizontal component of the resultant intensity and E_Y = vertical component of the resultant intensity Then $E_X = E_P - E_Q\cos\theta = (1.69 - 1.44 \times 0.8) \times 10^7$ to the left $= 0.538 \times 10^7\ N\ C^{-1}$ and $E_Y = E_R + E_Q \sin\theta = (3.0 + 1.44 \times 0.6) \times 10^7$ upwards $= 3.864 \times 10^7\ N\ C^{-1}$ Resultant intensity $= \sqrt{E_X^2 + E_Y^2}$ $= \sqrt{0.538^2 + 3.864^2} \times 10^7 = \mathbf{3.9 \times 10^7\ N\ C^{-1}}$	½ ½ ½ 1
	Total = 20	
6.(a)	(i) Capacitance is the ratio of the magnitude of charge on either plate to the potential difference between the plates.	1
	(ii) The dielectric strength of a dielectric is the maximum potential gradient the dielectric can withstand without its insulation breaking down.	1
(b)	The following arrangement, known as the vibrating-reed switch, may be used to investigate the relationship.  C is the capacitor formed by two large square plates separated by small pieces of polythene at the corners. When the vibrating reed makes contact with X, C gets charged and when it makes contact with Y, C is discharged. - A p.d V is set and the vibrating-reed is switched into operation. - V is noted and the current, I, registered by the galvanometer is also noted. Now, if f is the frequency of the reed switch and Q the charge acquired by C and discharged through G, the current $I = fQ$. Thus for a given frequency, $Q \propto I$ By varying V in steps of tens of volts the procedure is repeated using various values of V, each time noting the corresponding values of I. A graph of I against V is plotted. It is a straight line through the origin and since $Q \propto I$, it follows that $Q \propto V$.	1 ½ ½ ½ ½ ½ ½ ½ ½

(c)	 In series all the capacitors carry the same charge, Q but the potential differences are different as follows $V_1 = \frac{Q}{C_1}, \quad V_2 = \frac{Q}{C_2}, \quad V_3 = \frac{Q}{C_3},$ The total p.d across the network is $V = V_1 + V_2 + V_3 = Q\left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right)$ If C is the equivalent capacitance of the network, then $V = \frac{Q}{C} = Q\left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right)$ $\therefore \boldsymbol{\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}}$	1 ½ ½ ½ ½
(d)	(i) The voltmeter reading decreases. This is because the inserted material increases the capacitance of the arrangement. Since the charge has remained the same, the p.d drops (since Q = CV)	1 1
	(ii) The voltmeter reading rises Increasing the plate separation decreases capacitance. Since the charge has remained the same, the p.d increases	1 1
(e)	(i)  $4C_1 = 8$ $\therefore \quad C_1 = \mathbf{2\ \mu F}$ Also $\quad C_2(V - 4) = 8$ $C_2V - 4C_2 = 8$ ……….. (1) From the parallel connection: $(C_1 + C_2)V = 36$ …. (2) From (2) $\quad V = \frac{36}{C_1 + C_2}$ Substituting for V in (1), we have $\frac{36C_2}{C_1 + C_2} - 4C_2 = 8$	½ 1 ½ ½

	$\therefore C_2^2 - 5C_2 + 4 = 0$ $\therefore \quad C_2 = \frac{5 \pm \sqrt{25-16}}{2} = 1 \text{ or } 4$ So $C_2 = \mathbf{4\ \mu F}$	½ 1
	(ii) From above $V = \frac{36}{C_1 + C_2} = \frac{36}{2+4}$ $= \mathbf{6\ V}$	1 1
Total = 20		