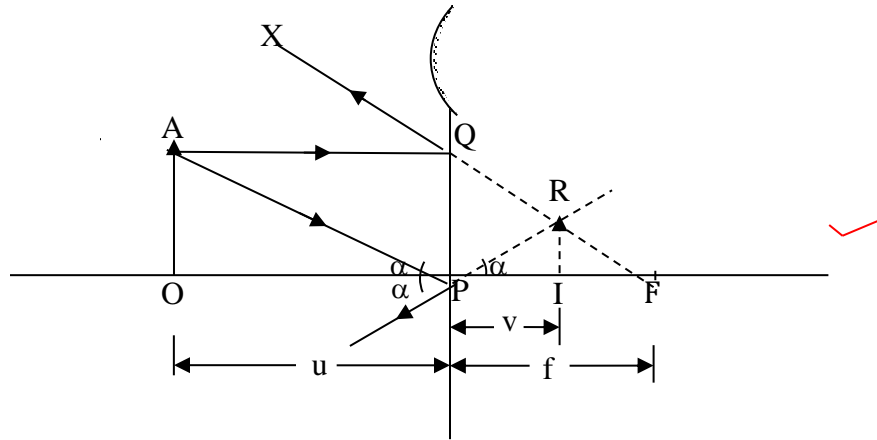




ALTERNATIVELY:

Take a point A on an object OA which is perpendicular to the principal axis.



A ray AP incident at the pole, is reflected at the same angle  $\alpha$ .  
 Another ray AQ, parallel to the principal axis, is reflected along QX and appears to come from the principal focus F.  
 The reflected rays appear to come from R, which therefore is the image of A.

So IR is the image of OA

Now  $\Delta AOP$  is similar to  $\Delta RIP$ .

$$\therefore \frac{IR}{OA} = \frac{IP}{OP} = \frac{-v}{u} \dots\dots\dots (1)$$

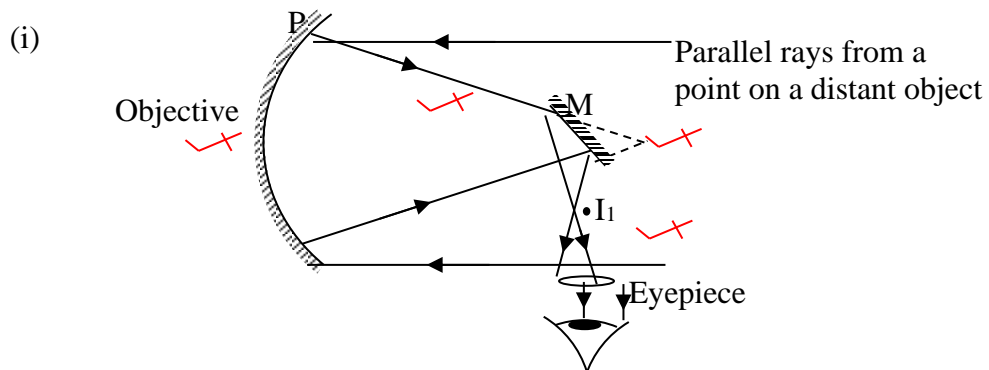
Also  $\Delta QPF$  is similar to  $\Delta RIF$ , and  $PQ = OA$

$$\therefore \frac{IR}{OA} = \frac{IF}{PF} = \frac{-f - (-v)}{-f} = \frac{f - v}{f} \dots\dots\dots (2)$$

From (1) and (2)  $\frac{-v}{u} = \frac{f - v}{f}$

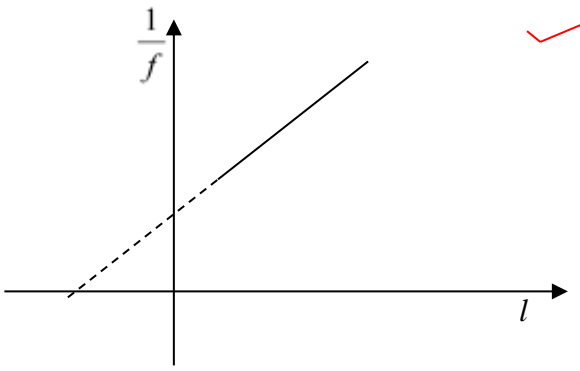
$$\therefore \frac{-v}{u} = 1 - \frac{v}{f} \quad \text{from which} \quad \frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

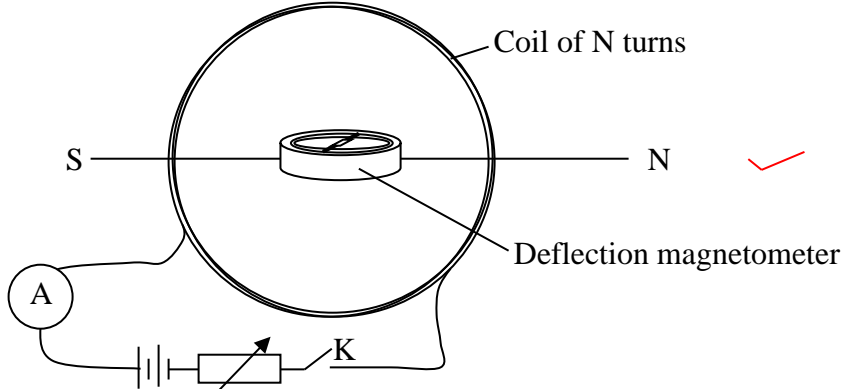
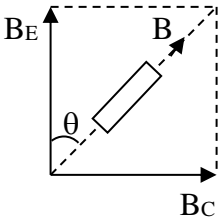
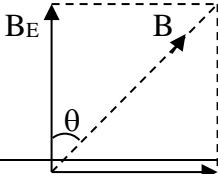
(c)



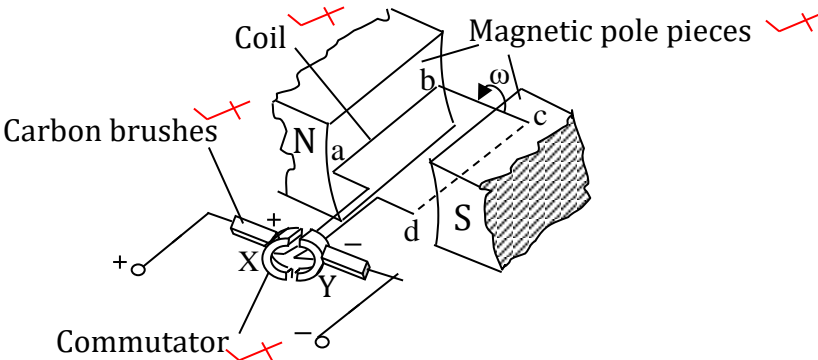
	<p>The telescope consists of a large parabolic mirror, P, which acts as the objective. ✓</p> <p>Rays from a point on a distant object arrive as a parallel beam at the objective which reflects the rays to a small plane mirror, M. ✓</p> <p>M reflects the beam to the side to form a real intermediate image, I<sub>1</sub>. ✓</p> <p>The eyepiece forms the final magnified image of I<sub>1</sub>. ✓</p>	<p>1</p> <p>1</p> <p>½</p> <p>½</p>
	<p>(ii) - No chromatic aberration</p> <p>- Image is brighter than for refractor type</p> <p>- One surface only has to be ground</p> <p>- Greater resolving power</p> <div style="border: 1px solid red; padding: 5px; display: inline-block; margin-left: 20px;">Any two @ 1</div>	<p>2</p>
(d)	<p>The eyepiece is u cm from the intermediate image and the final image is (84 + u - 64) cm from the eyepiece ✓</p> <p>i.e. 20 + u cm from the eyepiece</p> <p>Using <math>\frac{1}{v} + \frac{1}{u} = \frac{1}{f}</math> where v = -(20 + u) and f = 8 cm, we have</p> $\frac{1}{-(20+u)} + \frac{1}{u} = \frac{1}{8}$ <p>∴ u<sup>2</sup> + 20u - 160 = 0 from which u = -26.1 or 6.1 cm ✓</p> <p>We take 6.1 cm</p> <p>∴ Distance between the lenses = 84.0 + 6.1 ✓</p> <p style="text-align: center;">= <b>90.1 cm</b> ✓</p>	<p>1</p> <p>1</p> <p>1</p> <p>1</p> <p>1</p>
<b>Total = 20</b>		
2	<p>(i) A free oscillation is one in which the amplitude remains constant without additional energy input. ✓</p> <p>A damped oscillation is one whose amplitude decreases with time ✓</p>	<p>1</p> <p>1</p>
	<p>(ii) A wave is a travelling disturbance within a medium which allows transfer of energy from one point to another without any particles of the medium travelling between the two points. ✓</p>	<p>1</p>
(b)	<p>(i) x is the distance in the direction of the wave from some reference point. ✓</p>	<p>1</p> <p>1</p>

	<p><math>y</math> is the displacement of a particle from its equilibrium position at the distance <math>x</math>.</p>	✓
	<p>(ii) The equation is of the form <math>y = a \sin 2\pi \left( ft - \frac{x}{\lambda} \right)</math></p> <p><math>\therefore 0.4 = \frac{1}{\lambda} \Rightarrow \lambda = 2.5 \text{ m}</math> ✓</p> <p>and <math>f = 35 \text{ Hz}</math> ✓</p> <p>Velocity, <math>v = f\lambda = 35 \times 2.5 = 87.5 \text{ m s}^{-1}</math> ✓</p>	<p>1</p> <p>1</p> <p>1</p>
(c)	<p>(i) Resonance is an amplification of vibration of a system at its natural frequency due to impulses received from a source of the same frequency. ✓</p>	1
	<p>(ii)</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> </div> <div style="text-align: center;"> </div> </div> <p>- A resonance tube is almost filled with water ✓</p> <p>- A tuning fork is sounded near and above the mouth of the tube while the water level is allowed to fall gradually until resonance occurs. ✓</p> <p>- Then the length, <math>l</math>, of the air column is measured. ✓</p> <p>Then <math>l + c = \frac{1}{4} \lambda</math>, where <math>c</math> is the end correction. ✓</p> <p>But <math>\lambda = \frac{V}{f}</math>, where <math>V</math> is the velocity of sound in air and <math>f</math> is the frequency of the tuning fork.</p> <p><math>\therefore l + c = \frac{V}{4f}</math> ✓</p> <p>The procedure is repeated with tuning forks of different frequencies and a graph of <math>\frac{1}{f}</math> against <math>l</math> is plotted.</p>	<p>1</p> <p>1/2</p> <p>1</p> <p>1/2</p> <p>1/2</p> <p>1/2</p>

		1
	$\text{Gradient} = \frac{4}{V}$ $\therefore V = \frac{4}{\text{gradient}}$	1
(d)	(i) A harmonic is any possible frequency that can be produced by an instrument. ✓	1
	(ii) The wavelength for the fundamental note, $\lambda_0 = 2l$ ✓	1
	The fundamental frequency, $f_0 = \frac{V}{\lambda} = \frac{V}{2l}$ ✓	1
	The frequency of the 2 <sup>nd</sup> harmonic, $f_2 = 2f_0 = \frac{V}{l} = \frac{1}{l} \sqrt{\frac{T}{\mu}}$	
	Now, $\mu = \frac{5 \times 10^{-3}}{0.50} = 0.01 \text{ kg m}^{-1}$ ✓	1
	$\therefore f_2 = \frac{1}{0.50} \sqrt{\frac{100}{0.01}} = 2 \times 10^2 \text{ Hz}$ ✓	1
<b>Total = 20</b>		
3	(i) ... a vertical plane passing through both the magnetic north and south poles ✓	1
(a)	(ii) ... the angle between the magnetic meridian and the geographic meridian. ✓	1
(b)	From the equator the angle of dip increases from zero to 90° as one moves to the North pole. ✓	1
	This is because the direction of the magnetic field lines varies in the same manner ✓	1
	(i) $\frac{\mu NI}{2r}$ ✓	1

<p>(c)</p>	<p>(ii)</p>  <ul style="list-style-type: none"> <li>- A narrow coil of N turns is fixed with its plane lying in the magnetic meridian and is connected in series with an ammeter through a switch, K, to a d.c. source as shown in the diagram. ✓</li> <li>- The diameter, d, of the coil is measured and noted. ✓</li> <li>- A deflection magnetometer is placed at the centre of the coil, with its scale facing up and the position of the pointer is noted. ✓</li> <li>- Switch K is closed. The angle, <math>\theta_1</math>, turned through by the pointer is found and the reading, I, of the ammeter is noted. ✓</li> <li>- The procedure is repeated when the current is reversed and the deflection, <math>\theta_2</math>, is noted. ✓</li> </ul> <p>The average deflection, <math>\theta = \frac{1}{2} (\theta_1 + \theta_2)</math> is found</p> <p>Calculation:</p> <p>Let <math>B_E</math> = horizontal component of the Earth's magnetic flux density  <math>B_C</math> = magnetic flux density at the centre of the coil due to the current          The magnet of the magnetometer lies along the resultant of the two fields.</p>  <p>Thus <math>B_E = B_C \tan \theta</math> (See diagram) ✓</p> <p>But <math>B_C = \frac{\mu NI}{d}</math> ✓</p> <p><math>\therefore B_E = \frac{\mu NI}{d} \tan \theta</math> ✓</p>	<p>1</p> <p><math>\frac{1}{2}</math></p> <p><math>\frac{1}{2}</math></p> <p><math>\frac{1}{2}</math></p> <p><math>\frac{1}{2}</math></p> <p><math>\frac{1}{2}</math></p> <p><math>\frac{1}{2}</math></p> <p><math>\frac{1}{2}</math></p>
<p>(d)</p>	<p><math>N = 4, 2r = 0.14 \text{ m}, I = 0.35 \text{ A}, B = 1.8 \times 10^{-5} \text{ T}</math></p>  <p><math>B_C = \frac{\mu NI}{d}</math></p>	<p>1</p> <p>1</p>

	$= \frac{4\pi \times 10^{-7} \times 4 \times 0.35}{0.14} = 1.26 \times 10^{-5} \text{ T}$ $B = \sqrt{B_E^2 + B_C^2} = 10^{-5} \sqrt{1.8^2 + 1.26^2}$ $= 2.2 \times 10^{-5} \text{ T}$ <p>at an angle <math>\theta</math> to the magnetic meridian</p> <p>i.e. <math>\theta = \tan^{-1}\left(\frac{B_C}{B_E}\right) = \tan^{-1}\left(\frac{1.26}{1.80}\right) = 35^\circ</math></p>	<p>1/2</p> <p>1</p> <p>1/2</p> <p>1</p>
(e)	<p>(i) It is the torque exerted on a coil when it is placed with its plane parallel to a field of induction 1T.</p> <p>i.e. if the coil of N turns and area A is carrying a current I, then its magnetic moment is the quantity NIA.</p>	1
	<p>(ii) Radial magnetic field: This ensures that the plane of the coil is always parallel to the magnetic field in whatever angular position. <math>\Rightarrow</math> this results in the scale being linear.</p> <p>Fine hair springs: This provides the counter torque; and the weaker it is the more sensitive the galvanometer is.</p> <p>Large number of turns: This also ensures high sensitivity since the torque on the coil increases directly with the number of turns.</p> <p>A conducting former: This allows eddy currents to flow in it whenever the coil is moving. This results in damping of the oscillations of the coil, which is necessary.</p>	<p>1</p> <p>1</p> <p>1</p> <p>1</p> <p>1</p> <p>1</p>
<b>Total = 20</b>		
4	<p>(i) ... the coming into existence of an emf in a coil due to fluctuation of current which is flowing in the coil itself.</p>	1
(a)	<p>(ii) ... a current that circulates in a lump of conductor which is either rotated in a magnetic field or placed in a magnetic field of fluctuating strength.</p>	1
(b)	<p>(i) At first, as the current grows, a back emf is induced in L which resists flow of current through it.</p> <p>So current flows through A and B, which therefore light up.</p> <p>The supply p.d is shared between the two bulbs.</p> <p>When the current becomes steady, the back emf vanishes.</p>	<p>1/2</p> <p>1/2</p> <p>1/2</p> <p>1/2</p>

	<p>So the current now flows through A and L, bypassing B and all the supply p.d is now across A. Thus B dims out as A becomes brighter.</p>	<p>✓ ✓ ✓</p> <p>1/2 1/2</p>
	<p>(ii) A goes out while B shine brightly before going out. Opening K cuts off supply to A but as the current decays, an emf is induced in L, which is much greater than the supply p.d. This sends a high current through B for a brief time.</p>	<p>✓ ✓ ✓ ✓</p> <p>1 1 1/2 1/2</p>
(c)	<p>(i) When a motor is running, the sides of its coil sweep across the magnetic field of the assembly. By virtue of this, an emf is induced in the coil which, according to Lenz's law, opposes the change causing it. So it is against the supply – hence back emf.</p>	<p>✓ ✓</p> <p>1 1</p>
	<p>(ii) Back emf, <math>E_b = V - Ir = 240 - (5 \times 2) = 230 \text{ V}</math>                  The back emf is proportional to the speed of the coil.  <math>\therefore 3000k = 230 \dots\dots\dots (1)</math>                  When the current is 15 A, <math>E_b' = 240 - (15 \times 2) = 210 \text{ V}</math>  <math>\therefore nk = 210 \dots\dots\dots (2)</math>                  Eq(2) ÷ Eq(1): <math>\frac{n}{3000} = \frac{210}{230}</math>  <math>\therefore n = \frac{210}{230} \times 3000 = 2739 \text{ rev min}^{-1}</math></p>	<p>✓ ✓ ✓ ✓ ✓</p> <p>1/2 1/2 1/2 1</p>
(d)	<p>(i)</p>  <p>Suppose the coil is rotated anticlockwise. Then side ab moves downwards while dc upwards. According to Fleming's right hand rule, an emf is induced in the coil in the direction ba and another emf in the other side in the direction dc. The two emfs join up in series to constitute the output emf at the commutator parts X and Y.</p>	<p>✓ ✓ ✓ ✓ ✓ ✓</p> <p>1 1/2 1/2 1 1</p>



	<p>As the side ab crosses to the right and cd to the left, the parts X and Y of the commutator also interchange their contacts with the brushes so as to maintain the polarity at the brushes. ✓</p> <p>This is due to the fact that the induced emf in the coil reverses as the commutator contacts cross over.</p>	1
	<p>(ii)</p> <p style="text-align: right;">✓</p>	1
	<p>(iii)</p> <ul style="list-style-type: none"> <li>- direction of rotation of the coil. ✓</li> <li>- Direction of the magnetic field. ✓</li> </ul>	<p>½</p> <p>½</p>
<b>Total = 20</b>		
5 (a)	<p>(i) ...the number of joules of energy a source provides to drive one coulomb of electricity through the entire circuit, including the source itself. ✓</p>	1
	<p>(ii) ...the dissipative opposition to the flow of current offered by the materials of the source. ✓</p>	1
(b)	<p>(i) - length ✓</p> <p>- cross-sectional area ✓</p>	1
	<p>(ii) A metal consists of ions vibrating about their fixed mean positions surrounded by a “sea” of delocalised electrons. ✓</p> <p>At higher temperatures the kinetic energy of vibration is higher. ✓</p> <p>Since current is a drift of delocalised electrons, the drift of electrons is made harder when the ions are vibrating more violently. ✓</p> <p>So, resistance of the metal is higher at higher temperatures.</p>	<p>½</p> <p>1</p> <p>½</p>
	<p>(iii)</p> <p>The current I is the same in all the resistors</p> <p>The respective voltages, <math>V_1</math>, <math>V_2</math> and <math>V_3</math>, across the resistor <math>R_1</math>, <math>R_2</math> and <math>R_3</math>, are different.</p> <p>The total voltage applied to the combination is <math>V = V_1 + V_2 + V_3</math> ✓</p>	1

	<p>Now, if <math>R</math> is the equivalent resistance of the combination, then <math>V = IR</math> ✓                  But <math>V_1 = IR_1</math>, <math>V_2 = IR_2</math> and <math>V_3 = IR_3</math> ✓  <math>\therefore IR = IR_1 + IR_2 + IR_3</math> ✓  <math>\therefore R = R_1 + R_2 + R_3</math> ✓</p>	<p><math>\frac{1}{2}</math>  <math>\frac{1}{2}</math>                  1</p>
(c)	<p>Determination of Internal Resistance of a Cell</p> <ul style="list-style-type: none"> <li>- Using a certain length, <math>x</math>, of the bare wire, the circuit is connected as shown in the diagram. ✓</li> <li>- The switch is closed and the ammeter and voltmeter reading are noted. Let these be <math>I</math> and <math>V</math> respectively. ✓</li> <li>- The procedure is repeated using various values of <math>x</math>, each time noting the corresponding values of <math>I</math> and <math>V</math>. ✓</li> <li>- A graph of <math>V</math> against <math>I</math> is plotted ✓</li> </ul> <p>Now, if <math>E</math> is the emf of the cell and <math>r</math> the internal resistance, then ✓  <math>V = E - Ir</math>                  So, the magnitude of the gradient gives the internal resistance of the cell. ✓</p>	<p>1  <math>\frac{1}{2}</math>                  1  <math>\frac{1}{2}</math>  <math>\frac{1}{2}</math>  <math>\frac{1}{2}</math>  <math>\frac{1}{2}</math></p>
(d)	<p>(i) Let <math>I</math> = current flowing                  Then <math>E = 5I</math> ✓  <math>\therefore I = \frac{E}{5} = \frac{2}{5} = 0.4 \text{ A}</math> ✓                  Now <math>I(5 + 3 + R) = 2E</math> ✓  <math>\therefore 8 + R = \frac{2 \times 2}{0.4} = 10</math> ✓</p>	<p>1                  1                  1</p>

	$\therefore R = 10 - 8 = 2 \Omega$	✓	1
	(ii) Let V = voltmeter reading Then $V = E - 3I$ $= 2 - (3 \times 0.4)$ $= 2 - 1.2 = 0.8 \text{ V}$	✓	1
<i>Total = 20</i>			1