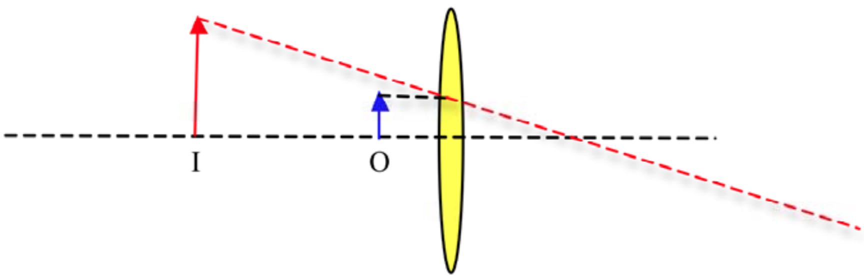
Mark scheme for Extension Worksheet – Option G, Worksheet 2

1 See diagram. Draw black line from top of object parallel to principal axis; join top of image to where black line intersects lens and extend until principal axis is intersected to give focal point on one side.



[2]

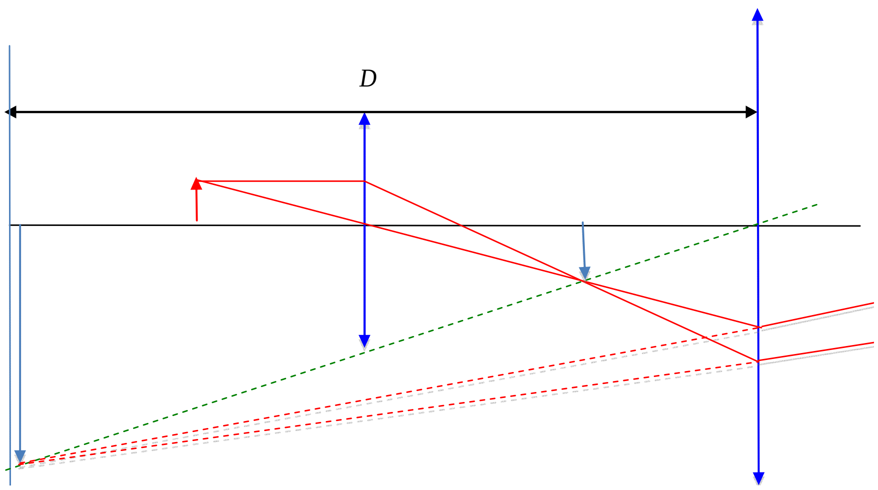
2 $\frac{1}{u}+\frac{1}{v}=\frac{1}{f} \Rightarrow \frac{1}{v}=\frac{1}{f}-\frac{1}{u}=\frac{1}{6.2}-\frac{1}{15} \Rightarrow v=10.6\text{ cm}$; so $M=-\frac{v}{u}=-\frac{10.6}{15}=-0.71$; so image is inverted, real and smaller. [3]

3 $\frac{1}{u}+\frac{1}{v}=\frac{1}{f} \Rightarrow \frac{1}{v}=\frac{1}{f}-\frac{1}{u}=\frac{1}{8.6}-\frac{1}{3.4} \Rightarrow v=-5.6\text{ cm}$; so $M=-\frac{v}{u}=-\frac{-5.6}{3.4}=+1.6$; so image is upright, virtual and larger. [3]

4 **a** $v=-D$; $\frac{1}{u}+\frac{1}{v}=\frac{1}{f} \Rightarrow \frac{1}{u}=\frac{1}{f}-\frac{1}{v}=\frac{1}{f}+\frac{1}{D}$; manipulating to get $u=\frac{fD}{f+D}$. [2]

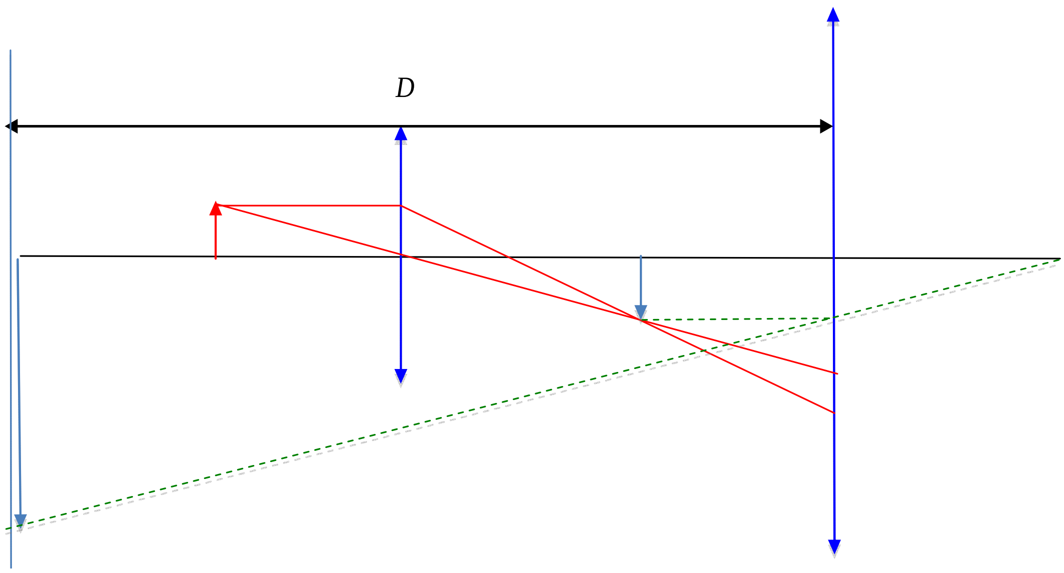
b $M=-\frac{v}{u}=-\frac{-D}{\frac{fD}{f+D}}$; so $M=+\frac{f+D}{fD}=1+\frac{D}{f}$ [2]

5 **a** Draw the green construction line as shown below and extend to distance of D to form image; now draw lines from image to lens where red rays arrive and extend each.



[3]

b Draw green line in diagram below parallel to principal axis to where you meet the lens; then join that point to image and extend to where principal axis is crossed to locate the focal point.



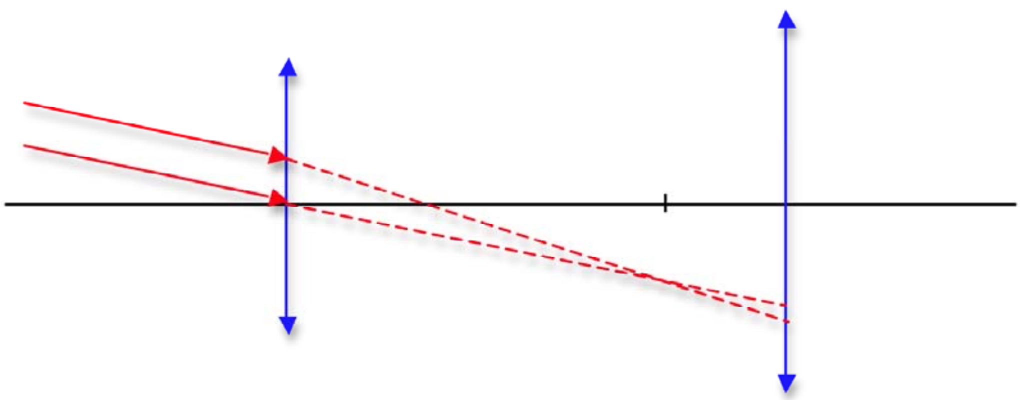
[2]

c The image in the objective is formed at:

$\frac{1}{u}+\frac{1}{v}=\frac{1}{f} \Rightarrow \frac{1}{v}=\frac{1}{f}-\frac{1}{u}=\frac{1}{2.0}-\frac{1}{2.5} \Rightarrow v=10$ cm ; so the magnification of the objective is $M=-\frac{v}{u}=-\frac{10}{2.5}=-4.0$; that of the eyepiece is

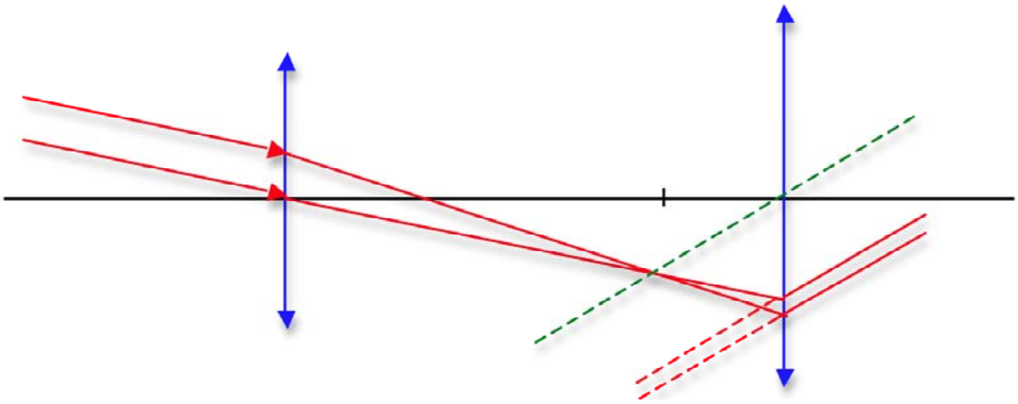
$M=1+\frac{D}{f}=1+\frac{25}{6.0}=5.2$ for an overall magnification of $-4.0\times 5.2=-21$ [3]

6 **a** See diagram. Ray through middle of lens goes through undeflected; other ray meets the first on the focal plane.



[2]

b See diagram. Green construction line; Red lines parallel to green line and extended backwards towards infinity.



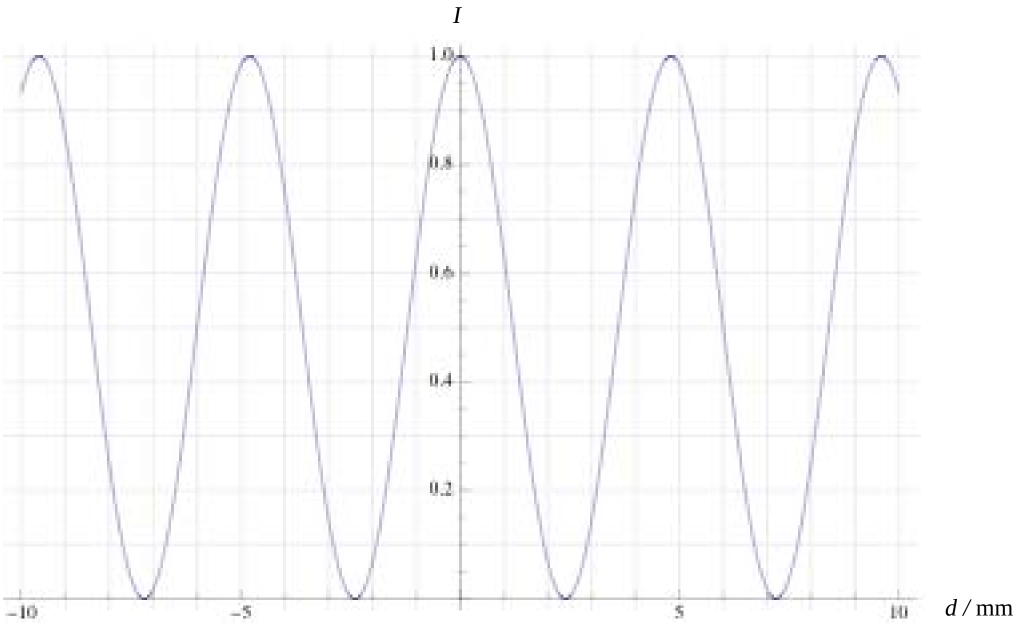
[2]

c $f=\dfrac{1}{P}=\dfrac{1}{50}=2.0\text{ cm}$; $M=\dfrac{f_o}{f_e}=\dfrac{120}{2.0}=60$ [2]

7 a In standard notation, the path difference is $d\sin\theta=n\lambda$ and becomes for small angles $d\tan\theta\approx n\lambda\Rightarrow d\dfrac{s_n}{D}\approx n\lambda$ where s_n is the distance of the nth bright fringe from the middle of the screen; the separation is then $s=s_{n+1}-s_n$; which becomes $s=\dfrac{(n+1)\lambda D}{d}-\dfrac{n\lambda D}{d}=\dfrac{\lambda D}{d}$ [3]

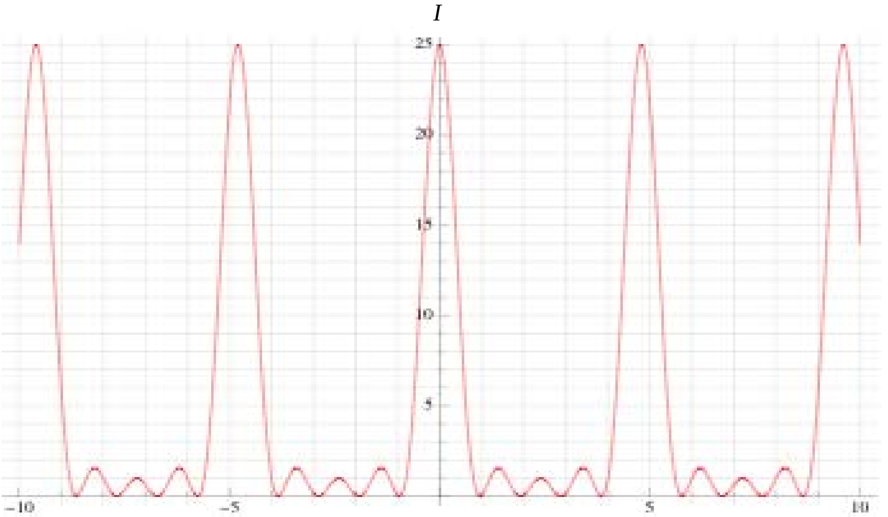
b $s=\dfrac{\lambda D}{d}\Rightarrow\lambda=\dfrac{sd}{D}$; $\lambda=\dfrac{4.8\times10^{-3}\times0.24\times10^{-3}}{1.80}=6.4\times10^{-7}\text{ m}$ [2]

c See graph in blue. Equal spacing; equal intensity.



[2]

d See graph, which is the curve for 5 slits. (Notice that the intensity is bigger by $5^2 = 25$ as much more light now goes through the slits.) Three from: higher intensity than with 2 slits; principal maxima at the same place; thinner; secondary maxima.



[3]

8 **a** $d\sin\theta = n\lambda$ and $d = \frac{1}{530}$ mm $= 1.89\times10^{-6}$ m so

$\sin\theta_1 = \frac{1\times540\times10^{-9}}{1.89\times10^{-6}} \Rightarrow \theta_1 = 16.6^\circ$; and $\sin\theta_2 = \frac{2\times540\times10^{-9}}{1.89\times10^{-6}} \Rightarrow \theta_2 = 34.8^\circ$;

so difference in angles is 18.2°. [3]

b At the limit, $\theta = 90^\circ$; so $1.89\times10^{-6}\sin90^\circ = n\times540\times10^{-9} \Rightarrow n = 3.5$, i.e. three orders. [2]

9 **a** $d = \frac{1}{660}$ mm $= 1.515\times10^{-6}$ m ; $\sin\theta_1 = \frac{1\times589.0\times10^{-9}}{1.515\times10^{-6}} \Rightarrow \theta_1 = 22.88^\circ$ and

$\sin\phi_1 = \frac{1\times589.6\times10^{-9}}{1.515\times10^{-6}} \Rightarrow \phi_1 = 22.90^\circ$ giving a difference in first order of

0.02°; in second order we have: $\sin\theta_2 = \frac{2\times589.0\times10^{-9}}{1.515\times10^{-6}} \Rightarrow \theta_2 = 51.04^\circ$ and

$\sin\phi_2 = \frac{2\times589.6\times10^{-9}}{1.515\times10^{-6}} \Rightarrow \phi_2 = 51.11^\circ$ and the difference is 0.07° [3]

b The angle is bigger and so easier to see the difference between the two wavelengths. [1]

