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Q1.

Formula for a lens connecting image distance (v), object distance (u) and the focal length (f) is:

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$$

This is the lens formula.

The lens formula has a minus sign (-) between 1/v and 1/u whereas the mirror formula has a plus sign (+) between 1/v and 1/u.

Mirror formula:

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$$

Q2.

Magnification (m) fomula for a lens is:

$$m=\frac{v(\text{distance of image})}{u(\text{distacne of object})}$$

Magnification formula for a mirror has a minus sign (-) but the magnification formula for a lens has no minus sign.

Magnification formula for a mirror is:

$$m=-\frac{v(\text{distance of image})}{u(\text{distacne of object})}$$

Q3.

The image will be virtual and erect, since the magnification has positive value.

Q4.

The image will be real and inverted, since the magnification has negative value.

Q5.

u = -10 cm, f = 10 cm

We have

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$$

$$\frac{1}{v}-\frac{1}{-10}=\frac{1}{10}$$

$$\frac{1}{v}=0$$

$$v=\frac{1}{0}=\infty$$

At infinity

Q6.

Since the object is placed at a distance greater than the focal length of the convex lens, so the image formed is real and inverted.

Q7.

$f = 12\,cm$
$m = 1$
$m = \frac{v}{u} = 1$
$\Rightarrow v = u$
Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
Putting the value of v, u and f,
$\frac{1}{u} - \frac{1}{-u} = \frac{1}{12}$ (image distance is negative)
$\frac{2}{u} = \frac{1}{12}$
$u = 24\,cm$
The object should be placed at a distance of 24 cm to from the lens (on the left side).

Q8.
New Cartesian Sign Convention for spherical lenses:
(i) All the distances are measured from the optical centre of the lens.
(ii) The distances measured in the same direction as that of incident light are taken as positive.
(iii) The distances measured against the direction of incident light are taken as negative.
(iv) The distances measured upward and perpendicular to the principal axis are taken as positive.
(v) The distances measured downward and perpendicular to the principal axis are taken as negative.
Q9.
$u = -10\,cm$
$h_1 = 4\,cm$
$f = 20\,cm$
$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$
$$\frac{1}{v} - \frac{1}{-10} = \frac{1}{20}$$
$$\frac{1}{v} = \frac{1}{20} - \frac{1}{10} = -\frac{1}{20}$$
$v = -20\,cm$ (Image is 20 cm in front of the convex lens)
$$m = \frac{v}{u} = \frac{20}{-10} = -2$$
$$m = \frac{h_2}{h_1} = -2$$
$$\frac{h_2}{4} = -2$$
$h_2 = -8\,cm$
Image is 8 cm in size and is real and inverted.

Q10.

$$f = 5\,cm$$
$$v = -25\,cm \text{ (Virtual image)}$$
Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$$\frac{1}{-25} - \frac{1}{u} = \frac{1}{5}$$
$$\frac{1}{u} = -\frac{1}{25} - \frac{1}{5} = -\frac{6}{25}$$
$$u = -\frac{25}{6}\,cm$$
Magnification, $m = \frac{v}{u} = \frac{-25}{-25/6} = +6$

Q11.

$h_1 = 5\,cm$

$u = -10\,cm$

$f = 6\,cm$

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$
$$\frac{1}{v} - \frac{1}{-10} = \frac{1}{6}$$
$$\frac{1}{v} = \frac{1}{6} - \frac{1}{10} = \frac{2}{30} = \frac{1}{15}$$
$v = 15\,cm$

Image is formed 15cm behind the convex lens and it is real and inverted.

Q12.

$$v = -50\,cm \text{ (Virtual image)}$$
$$u = -20\,cm$$
$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$
$$\frac{1}{-50} - \frac{1}{-20} = \frac{1}{f}$$
$$\frac{-2+5}{100} = \frac{1}{f}$$
$$\frac{3}{100} = \frac{1}{f}$$
$$f = 33.3\,cm$$

Q13.

(i) Since the object is placed at a distance greater than the focal length of the lens, so the image formed is real and inverted.

(ii) u = -100cm, f = 40cm

Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$$\frac{1}{v} - \frac{1}{-100} = \frac{1}{40}$$
$$\frac{1}{v} = \frac{1}{40} - \frac{1}{100}$$
$$\frac{1}{v} = \frac{5-2}{200} = \frac{3}{200}$$
$v = 66.6\,cm$

Image is formed 66.6 cm behind the convex lens.

Q14.

$m = -3$ (Inverted image)
$u = -15cm$
$m = \frac{v}{u}$
$-3 = \frac{v}{-15}$
$v = 45cm$
Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$\frac{1}{45} - \frac{1}{-15} = \frac{1}{f}$
$\frac{1+3}{45} = \frac{1}{f}$
$f = \frac{45}{4}cm$
$f = 11.25cm$

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Q15.

$f = 5cm$
$u = -20cm$
$v = +v$ (since image is real)
Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$\frac{1}{v} - \frac{1}{-20} = \frac{1}{5}$
$\frac{1}{v} = \frac{1}{5} - \frac{1}{20} = \frac{4-1}{20} = \frac{3}{20}$
$v = 6.66$

Q16.

$h_1 = 5\text{cm}$

$u = -25\text{cm}$

$f = 10\text{cm}$

Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$$\frac{1}{v} - \frac{1}{-25} = \frac{1}{10}$$

$$\frac{1}{v} = \frac{1}{10} - \frac{1}{25} = \frac{5-2}{50} = \frac{3}{50}$$

$v = 16.6$

Image is 16.6cm behind the convex lens.

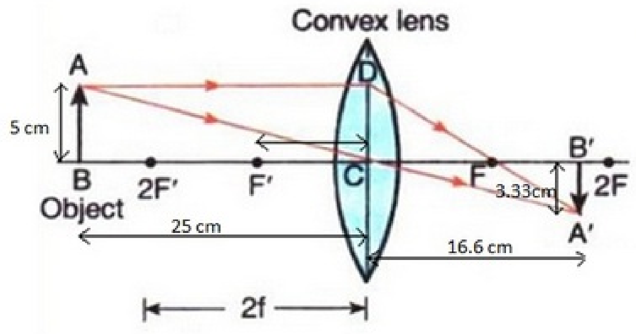
$m = \frac{v}{u} = \frac{50/3}{-25} = -\frac{2}{3}$ (Image is real and inverted)

$$m = \frac{h_2}{h_1}$$

$$-\frac{2}{3} = \frac{h_2}{5}$$

$$h_2 = \frac{-10}{3} = -3.33\text{cm}$$

Image is 3.33 cm in size and is real and inverted.



Q17.

$f = 18\text{cm}$

$v = 24\text{cm}$

Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$$\frac{1}{24} - \frac{1}{u} = \frac{1}{18}$$

$$\frac{1}{u} = \frac{1}{24} - \frac{1}{18}$$

$$\frac{1}{u} = \frac{3-4}{72} = \frac{-1}{72}$$

$u = -72\text{cm}$

$$m = \frac{v}{u} = \frac{24}{-72} = -\frac{1}{3}$$

Q18.

$h_1 = 2\text{cm}$

$f = 5\text{cm}$

$u = -10\text{m} = -1000\text{cm}$

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$$\frac{1}{v} - \frac{1}{-1000} = \frac{1}{5}$$

$$\frac{1}{v} = \frac{1}{5} - \frac{1}{1000} = \frac{200-1}{1000} = \frac{199}{1000}$$

$v = 5.02\text{cm}$

The image is formed 5.02 cmbehind the convex lens and is real and inverted.

$m = \frac{v}{u} = \frac{5.02}{-1000} = -0.005$

$m = \frac{h_2}{h_1} = -0.005$

$\frac{h_2}{2} = -0.005$

$h_2 = -0.01\text{cm}$

Since the object distance is much greater than the focal length, this example illustrates the case when the object is place

Q19.

$-u + v = 80\,\text{cm} \quad - - - - - (1)$

$m = -3$ (The image is real, since it forms on a screen)

$m = \frac{v}{u} = -3$

$v = -3u$

Put in eq (1),

$-u - 3u = 80$

$-4u = 80$

$u = -20\,\text{cm}$

Distance of lens from filament is 20cm.

$v = -3u = 60\,\text{cm}$

Lens fornula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\frac{1}{60} - \frac{1}{-20} = \frac{1}{f}$

$\frac{1}{f} = \frac{1+3}{60} = \frac{4}{60}$

$f = 15\,\text{cm}$

Q20.

$h_2 = 2\,\text{cm}$ (Erect image)

$v = -12\,\text{cm}$ (Erect image)

$h_1 = 0.5\,\text{cm}$

$m = \frac{v}{u} = \frac{h_2}{h_1}$

$\frac{-12}{u} = \frac{2}{0.5}$

$u = -3\,\text{cm}$

Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\frac{1}{-12} - \frac{1}{-3} = \frac{1}{f}$

$\frac{-1+4}{12} = \frac{1}{f}$

$f = 4\,\text{cm}$

Q21.

$$f = 0.10\,m$$
$$h_1 = 5\,mm = 0.005\,m$$
$$u = -0.08\,m$$
Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$$\frac{1}{v} - \frac{1}{-0.08} = \frac{1}{0.10}$$
$$\frac{1}{v} = \frac{1}{0.10} - \frac{1}{0.08}$$
$$v = -0.4\,m$$
Image is formed 0.40 m in front of the convex lens.
$$m = \frac{v}{u} = \frac{h_2}{h_1}$$
$$\frac{-0.4}{-0.08} = \frac{h_2}{0.005}$$
$$h_2 = 0.025\,m = 25\,mm$$
Size of image is 25 mm.

Image is virtual and erect.

Q22.

$$f = 6\,cm$$
$$u = -4\,cm$$
$$h_1 = 0.5\,cm$$
Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$$\frac{1}{v} - \frac{1}{-4} = \frac{1}{6}$$
$$\frac{1}{v} = \frac{1}{6} - \frac{1}{4} = \frac{2-3}{12}$$
$$v = -12\,cm$$
$$m = \frac{v}{u} = \frac{h_2}{h_1}$$
$$\frac{-12}{-4} = \frac{h_2}{0.5}$$
$$h_2 = 1.5\,cm$$
Image is 1.5 cm high, virtual, erect and magnified.

Q23.

$$f = 10\,cm$$
$m = +4$ (upright image)
$$m = \frac{v}{u} = 4$$
$$v = 4u$$
Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$$\frac{1}{4u} - \frac{1}{u} = \frac{1}{10}$$
$$\frac{-3}{4u} = \frac{1}{10}$$
$$u = -7.5\,cm$$
The object must be placed 7.5 cm in front of the converging lens.

Q24.

$$f = 20\text{cm}$$
$$m = -10 (\text{Image is real})$$
$$u = ?$$
$$m = \frac{v}{u} = -10$$
$$v = -10u$$
Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$$\frac{1}{-10u} - \frac{1}{u} = \frac{1}{20}$$
$$\frac{-1-10}{10u} = \frac{1}{20}$$
$$\frac{-11}{10u} = \frac{1}{20}$$
$$u = -22\text{cm}$$
$$v = -10 \times -22 = 220\text{ cm}$$

Q25.

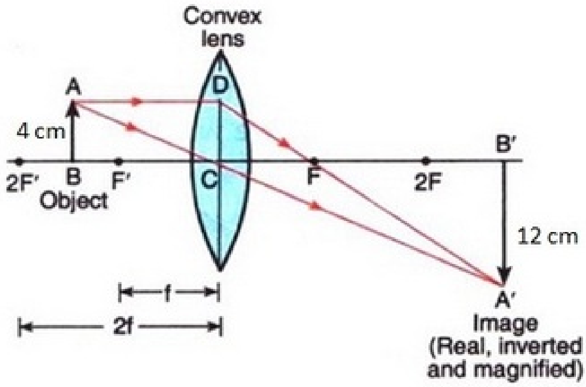
$u = -4$ cm

$v = 12$ cm (Real image)

(a) $m = \frac{v}{u} = \frac{12}{-4} = -3$

(b) Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$$\frac{1}{12} - \frac{1}{-4} = \frac{1}{f}$$
$$\frac{1+3}{12} = \frac{1}{f}$$
$f = 3$ cm

(c)



Q26.

(a) $h_1 = 2$ cm
$f = 8$ cm
(i) $u = -12$ cm

Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\frac{1}{v} - \frac{1}{-12} = \frac{1}{8}$

$\frac{1}{v} = \frac{1}{24}$

$v = 24\text{cm}$

Image is 24 cm behind the lens.

$m = \frac{v}{u} = \frac{h_2}{h_1}$

$\frac{24}{-12} = \frac{h_2}{2}$

$h_2 = -4\text{cm}$

Image is 4 cm high, real and inverted.

(ii) $u = -6$ cm

Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\frac{1}{v} - \frac{1}{-6} = \frac{1}{8}$

$\frac{1}{v} = -\frac{1}{24}$

$v = -24\text{cm}$

Image is 24 cm in front of the lens.

$m = \frac{v}{u} = \frac{h_2}{h_1}$

$\frac{-24}{-6} = \frac{h_2}{2}$

$h_2 = 8\text{cm}$

Image is 8 cm high, virtual and erect.

(b) (i) Used in film projector.
(ii) Used as a magnifying glass.

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Q27.

(a) $h_1 = 3cm$
$u = -24cm$
$f = 8cm$

Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\frac{1}{v} - \frac{1}{-24} = \frac{1}{8}$

$\frac{1}{v} = \frac{1}{12}$

$v = 12cm$

Image is formed 12 cm behind the lens.

$m = \frac{v}{u} = \frac{h_2}{h_1}$

$\frac{12}{-24} = \frac{h_2}{3}$

$h_2 = -1.5cm$

Image is 1.5cm high, real and inverted.

(b) u=-3cm
$h_1 = 3cm$
$f = 8cm$

Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\frac{1}{v} - \frac{1}{-3} = \frac{1}{8}$

$\frac{1}{v} = -\frac{5}{24}$

$v = -4.8cm$

Image is formed 4.8 cm in front of the lens.

$m = \frac{v}{u} = \frac{h_2}{h_1}$

$\frac{-4.8}{-3} = \frac{h_2}{3}$

$h_2 = +4.8cm$

Image is 4.8cm high, virtual and erect.

(c) Case (b)

Q28.

(a) f=0.20 m

(i) u=-0.50 m

Lens formula: $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$

$$\frac{1}{v}-\frac{1}{-0.50}=\frac{1}{0.20}$$

$$\frac{1}{v}=\frac{1}{0.20}-\frac{1}{0.50}$$

$$v=0.33\,m$$

Image is formed 0.33 m behind the lens.

$$m=\frac{v}{u}=\frac{0.33}{-0.50}=-0.66$$

Image is real and inverted.

(ii) u=-0.25 m

Lens formula: $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$

$$\frac{1}{v}-\frac{1}{-0.25}=\frac{1}{0.20}$$

$$\frac{1}{v}=\frac{1}{0.20}-\frac{1}{0.25}$$

$$v=1\,m$$

Image is formed 1 m behind the lens.

$$m=\frac{v}{u}=\frac{1}{-0.25}=-4$$

Image is real and inverted.

(iii) u=-0.15 m

Lens formula: $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$

$$\frac{1}{v}-\frac{1}{-0.15}=\frac{1}{0.20}$$

$$\frac{1}{v}=\frac{1}{0.20}-\frac{1}{0.15}$$

$$v=-0.60\,m$$

Image is formed 0.60 m in front of the lens.

$$m=\frac{v}{u}=\frac{-0.6}{-0.15}=+4$$

Image is virtual and erect.

(b) Film projector: Case (ii)

Camera: Case (i)

Magnifying glass: Case (iii)

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Q41.

(a) 100 cm; 60 cm; 40 cm; 30 cm; 24 cm

(b) When u=-25 cm, v=100 cm

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$$

$$\frac{1}{100}-\frac{1}{-25}=\frac{1}{f}$$

$$\frac{1}{f}=\frac{5}{100}$$

$$f=20\text{cm}$$

When u=-90 cm, v=?

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$$

$$\frac{1}{v}-\frac{1}{-90}=\frac{1}{20}$$

$$\frac{1}{v}=\frac{1}{20}-\frac{1}{90}$$

$$\frac{1}{v}=\frac{7}{180}$$

$$v=25.7\text{ cm}$$

(c) 25 cm

(d) 20 cm (As calculated in part (b))

Q42.

$f = 100\text{ mm}$

$h_1 = 16\text{ mm}$

$v = -25\text{cm} = -250\text{mm}$

(a) $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$

$$\frac{1}{-250}-\frac{1}{u}=\frac{1}{100}$$

$$\frac{1}{u}=-\frac{7}{500}$$

$u = -71.4\text{mm} = -7.14\text{cm}$

Distance between object and lens is 7.14 cm.

(b) The object should be placed at the focus so that the image is formed at infinity.

So, u = -100 mm = -10 cm

The object should be placed 10 cm in front of the lens.

Q43.

$$h_2 = -3\,\text{cm (Real image)}$$
$$h_1 = 1\,\text{cm}$$
$$-u + v = 15\,\text{cm}$$
$$m = \frac{v}{u} = \frac{h_2}{h_1}$$
$$\frac{15+u}{u} = \frac{-3}{1}$$
$$15+u = -3u$$
$$u = -3.75\,\text{cm}$$
$$v = 15+u = 15+(-3.75) = 11.25\,\text{cm}$$
$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$
$$\frac{1}{11.25} - \frac{1}{-3.75} = \frac{1}{f}$$
$$f = 2.82\,\text{cm}$$

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Q44.

$$h_1 = 50\,\text{cm}$$
$$h_2 = -20\,\text{cm (Real image)}$$
$$v = 10\,\text{cm}$$
$$m = \frac{v}{u} = \frac{h_2}{h_1}$$
$$\frac{10}{u} = \frac{-20}{50}$$
$$u = -25\,\text{cm}$$
$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$
$$\frac{1}{10} - \frac{1}{-25} = \frac{1}{f}$$
$$f = \frac{50}{7} = 7.14\,\text{cm}$$

*********** END **********