AP® Physics B
2003 Sample Student Responses
Form B

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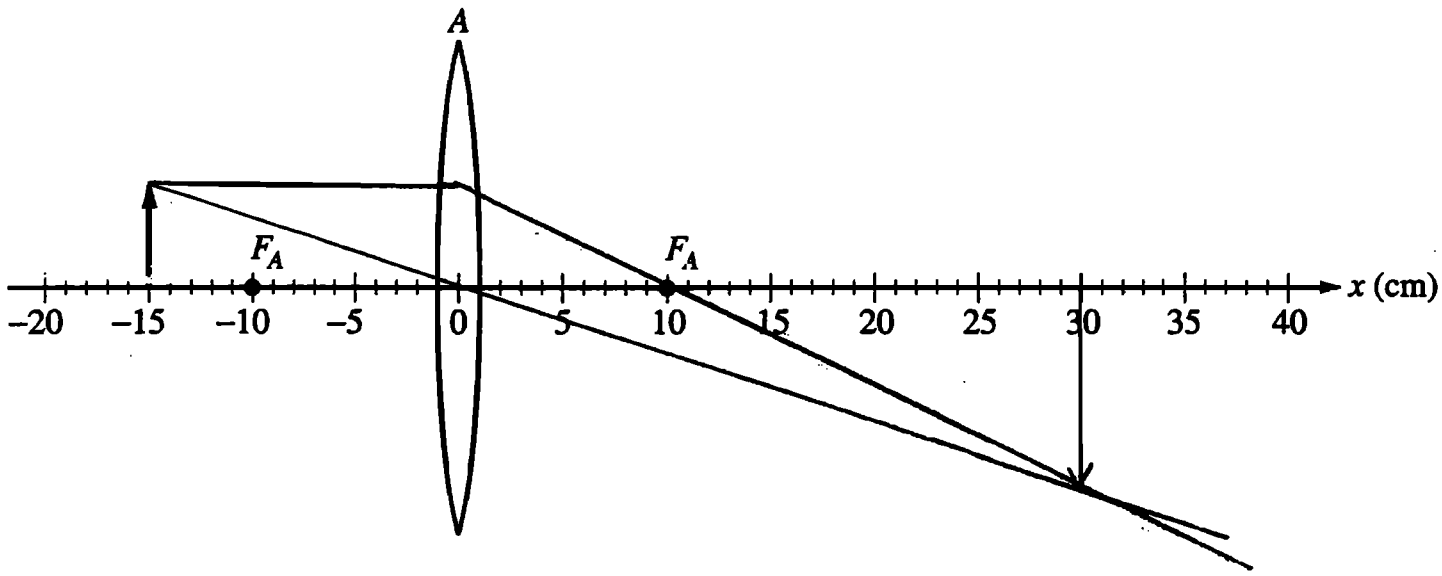

3. (15 points)
A thin convex lens A of focal length $f_A = 10$ cm is positioned on an x-axis as shown above. An object of height 5 cm, represented by the arrow, is positioned 15 cm to the left of lens A.

(a) On the figure above, draw necessary rays and sketch the image produced by lens A.

(b) Calculate the location of the image produced by lens A.

Cal Si

$\frac{1}{Si} + \frac{1}{So} = \frac{1}{f}$

$\frac{1}{Si} = \frac{1}{f} - \frac{1}{So}$

$= \frac{1}{10cm} - \frac{1}{15cm}$

$Si = 30cm$

$\therefore Si = 30cm$

(c) Calculate the height of the image produced by lens A.

Cal hi

$M = \frac{hi}{ho}$ $\quad M = -\frac{Si}{So}$

$\frac{hi}{ho} = -\frac{Si}{So}$

$hi = -\frac{Si \cdot ho}{So}$

$= -\frac{30cm \times 5cm}{15cm}$

$= -10cm$

$\therefore hi = 10cm$ downwards
$(= -10cm)$

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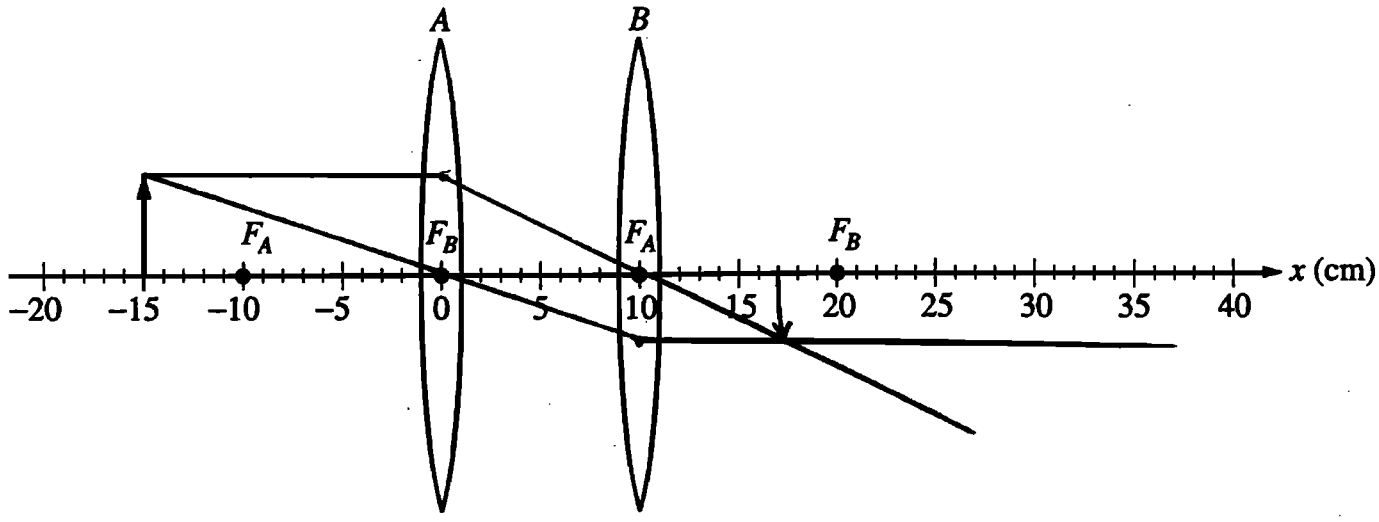

A second thin convex lens B of focal length $f_B = 10$ cm is now positioned 10 cm to the right of lens A, as shown above.

(d) Determine the location on the x-axis given above of the final image produced by the combination of lenses.

Let's assume F_A is at 0 cm

→ F_B = −10 cm & object is at −25cm

Cal S_i

$\frac{1}{S_i} + \frac{1}{S_o} = \frac{1}{f}$

$\frac{1}{S_i} = \frac{1}{f} - \frac{1}{S_o}$

$= \frac{1}{F_B} - \frac{1}{S_o}$

$= \frac{1}{10cm} - \left(\frac{1}{25cm}\right)$

$S_i \approx 17$ cm

$\therefore S_i = 17$cm

(e) Check the appropriate spaces below to indicate the characteristics of the final image produced by the combination of lenses.

- ✓ inverted
- ____ upright
- ____ larger than the original object
- ✓ smaller than the original object

Explain your answers.

Inverted: Rays start from the tip of the arrow (upright) and they meet at one point below x-axis. This indicates the tip of the arrow points downwards, thus inverted.

Smaller: According to the calculation below determining the length of the image, the final image is 3.4cm, thus smaller than the real object.

Cal h_i

$\frac{h_i}{h_o} = -\frac{S_i}{S_o}$

$h_i = -\frac{S_i h_o}{S_o}$

$= -\frac{(17cm)(5cm)}{25cm}$

$= -3.4cm$

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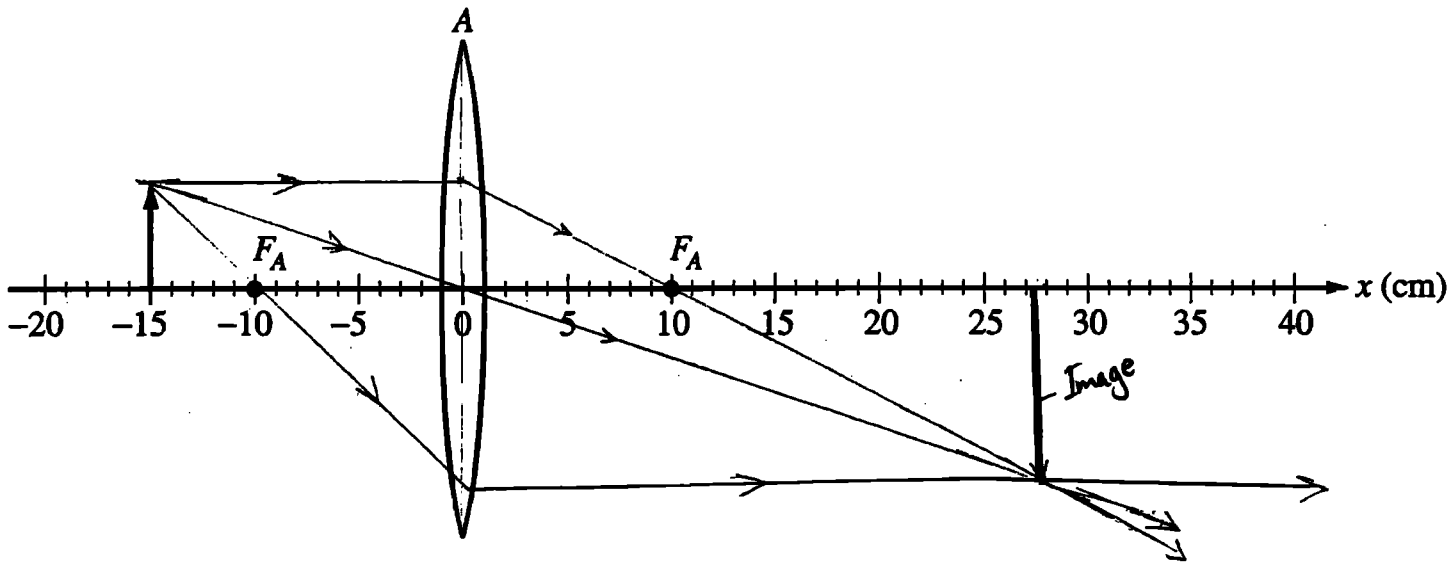

3. (15 points)
A thin convex lens A of focal length $f_A = 10$ cm is positioned on an x-axis as shown above. An object of height 5 cm, represented by the arrow, is positioned 15 cm to the left of lens A.

(a) On the figure above, draw necessary rays and sketch the image produced by lens A.

(b) Calculate the location of the image produced by lens A.

$1/d_o + 1/d_i = 1/f$

$\therefore 1/d_i = 1/f - 1/d_o$

$1/d_i = 1/10 - 1/15 = 1/30$

$\therefore d_i = 30\,cm.$

∴ Image position = 30 cm behind the lens.

(c) Calculate the height of the image produced by lens A.

$M = \frac{-d_i}{d_o} = -\frac{+30}{15} = -2$

$\therefore h_o = |M| d_i$

$= 2 \times 5\,cm = 10\,cm.$

∴ Height of the image = 10 cm.

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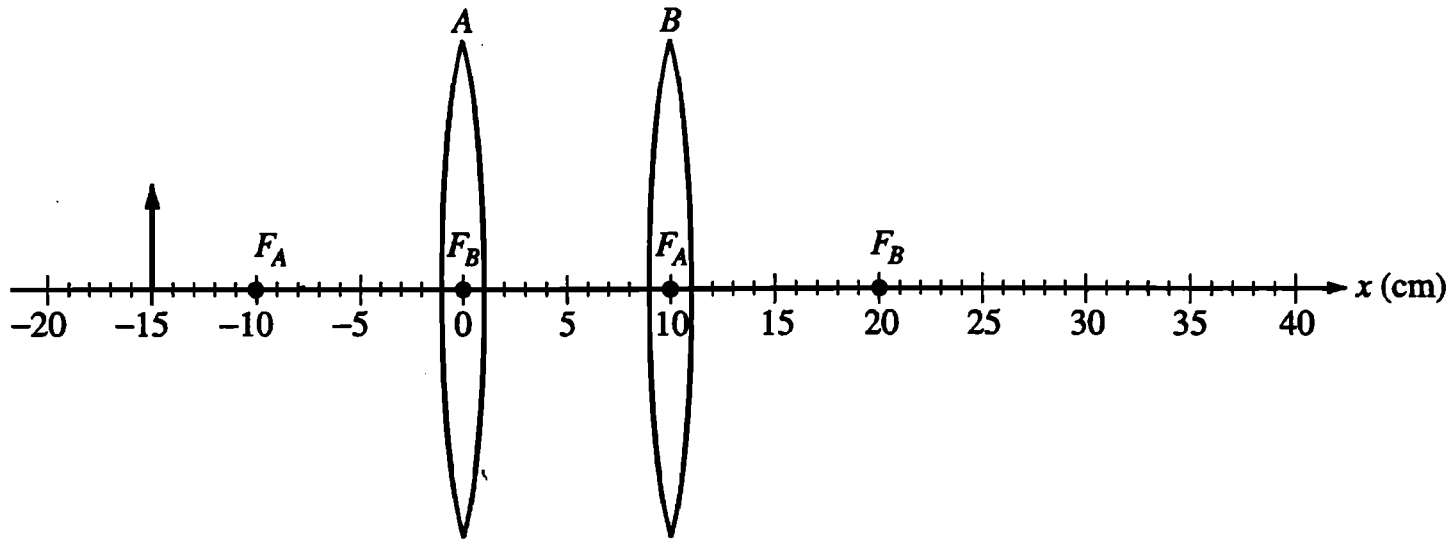

A second thin convex lens B of focal length $f_B = 10$ cm is now positioned 10 cm to the right of lens A, as shown above.

(d) Determine the location on the x-axis given above of the final image produced by the combination of lenses.

$\therefore d_o = 20$ cm from lens B, virtual image.

$\therefore 1/d_i = 1/f - 1/d_o$

$= 1/10 + +1/20 = 3/20$

$\therefore d_i = 6.67$ cm.

$\therefore$ Image position = 6.67cm to the right of lens B.

$d_i/d_o = -B/20$

(e) Check the appropriate spaces below to indicate the characteristics of the final image produced by the combination of lenses.

____ inverted

__√__ upright

____ larger than the original object

__√__ smaller than the original object

Explain your answers.