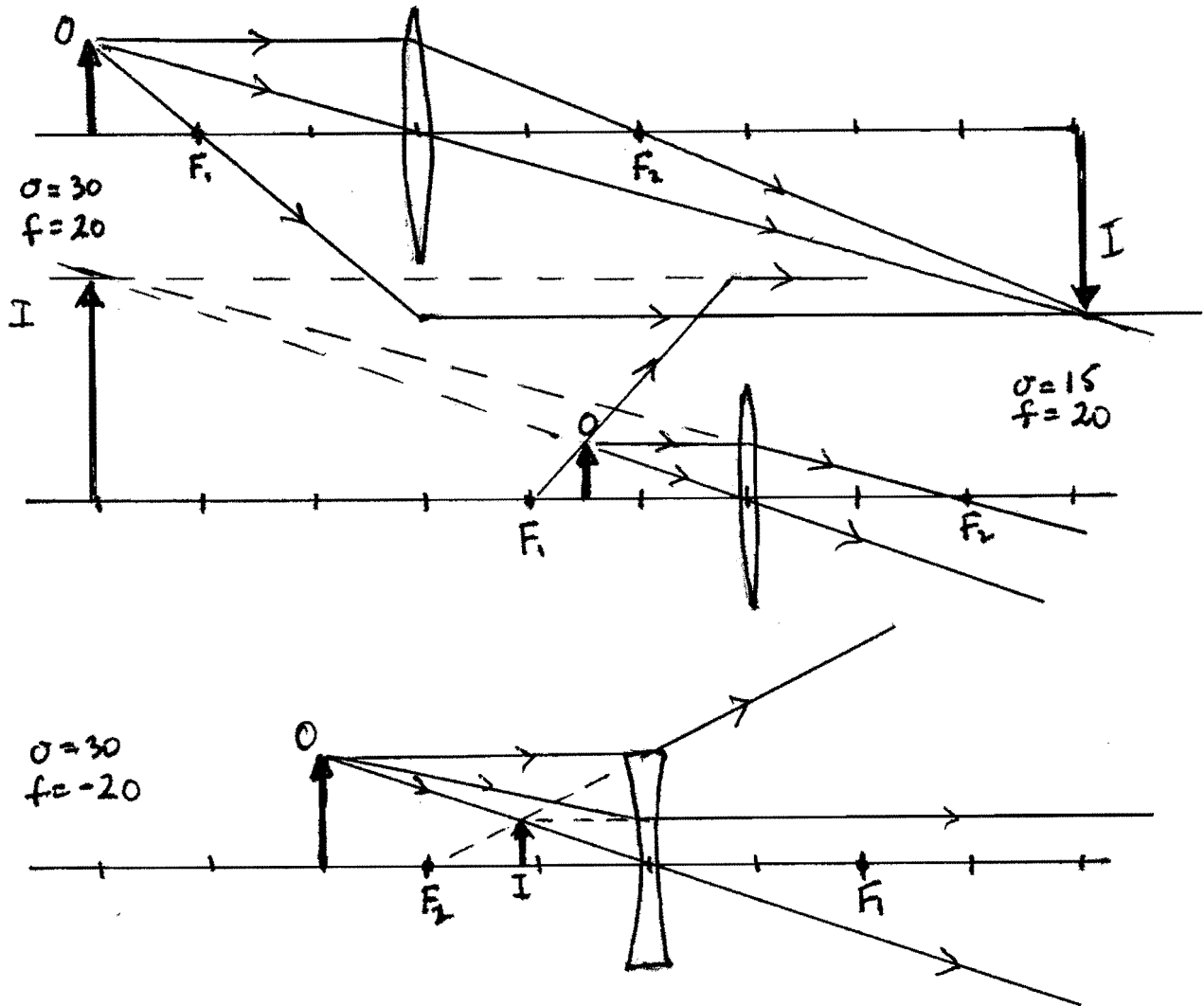


Fill in the blanks. Insert signs where they are missing. Show your calculations on a separate sheet.

|   | Type       | $f$  | $o$  | $i$  | $m$  | Real? | Inverted? |
|---|------------|------|------|------|------|-------|-----------|
| A | Converging | +10  | +20  | +20  | -1   | Y     | Y         |
| B | Converging | +10  | +5.0 | -10  | +2   | N     | N         |
| C | Converging | +10  | +5.0 | -10  | >1.0 | N     | N         |
| D | Diverging  | -10  | +5.0 | -3.3 | <1.0 | N     | N         |
| E | Diverging  | -10  | +10  | -5   | +0.5 | N     | No        |
| F | Converging | +3.3 | +10  | +5   | -0.5 | Y     | Y         |

In each case below, find the final image and the magnification using (a) graphical techniques and (b) algebra. Show your work and label the ray diagram clearly. Do not try to make the ray diagrams freehand – use a ruler.



$$\textcircled{A} \quad f = +10 \quad \frac{1}{i} = \frac{1}{f} - \frac{1}{o} = \frac{1}{10} - \frac{1}{20} = \frac{1}{20} \Rightarrow i = +20$$

$$m = -i/o = -20/20 = -1$$

$$\textcircled{B} \quad f = +10 \Rightarrow \text{Converging} \quad \frac{1}{i} = \frac{1}{f} - \frac{1}{o} = \frac{1}{10} - \frac{1}{5} = -\frac{1}{10} \Rightarrow i = -10$$

$$m = -i/o = -(-10)/5 = +2$$

$$\textcircled{C} \quad m > 1 \Rightarrow \text{Converging} \Rightarrow f = +10 \quad \frac{1}{f} = \frac{1}{10} - \frac{1}{5} \Rightarrow i = -10$$

$$\textcircled{D} \quad m < 1 \Rightarrow \text{Diverging (for } o < f) \Rightarrow f = -10$$

$$\frac{1}{i} = \frac{1}{f} - \frac{1}{o} = \frac{1}{-10} - \frac{1}{5} = -\frac{3}{10} \Rightarrow i = -3.3$$

$$\textcircled{E} \quad \text{Non-inverted image with } |m| < 1 \Rightarrow \text{Diverging lens}$$

$$m = +0.5 = -i/o \Rightarrow i = -5 \quad \frac{1}{f} = \frac{1}{o} + \frac{1}{i} = \frac{1}{10} - \frac{1}{5} = -\frac{1}{10}$$

$$\textcircled{F} \quad m = -0.5 = -i/o \Rightarrow i = +5 \quad \frac{1}{f} = \frac{1}{o} + \frac{1}{i} = \frac{1}{10} + \frac{1}{5} \Rightarrow f = 3.3$$

$$\text{1}^{\text{st}} \text{ figure: } \frac{1}{i} = \frac{1}{f} - \frac{1}{o} = \frac{1}{20} - \frac{1}{30} = \frac{1}{60} \Rightarrow i = +60$$

$$m = -i/o = -60/30 = -2.0$$

$$\text{2}^{\text{nd}} \text{ figure: } \frac{1}{i} = \frac{1}{f} - \frac{1}{o} = \frac{1}{20} - \frac{1}{15} = -\frac{1}{60} \Rightarrow i = -60$$

$$m = -i/o = -(-60)/15 = +4.0$$

$$\text{3}^{\text{rd}} \text{ figure: } \frac{1}{i} = \frac{1}{f} - \frac{1}{o} = \frac{1}{-20} - \frac{1}{30} = -\frac{1}{12} \Rightarrow i = -12$$

$$m = -i/o = -(-12)/30 = +0.4$$