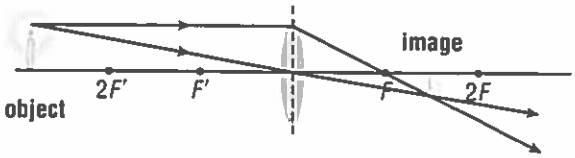
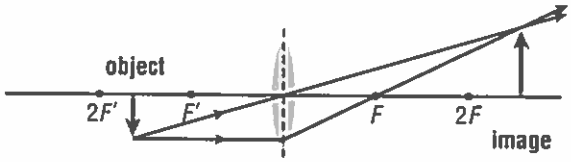
(iv) One ray from the object arrow point goes parallel to the principal axis and refracts aligned with *F*. A second ray goes unbent through *O*. These rays diverge and must be traced back to the image of the arrow point on the same side of the principal axis as the object arrow.

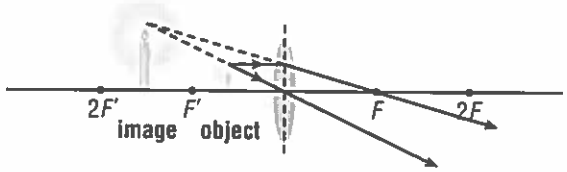
(b) **(i)** smaller than the object, inverted, located between 2*F* and *F*, real



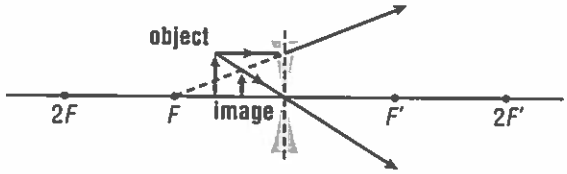
(ii) larger than the object, inverted, located beyond 2*F*, real



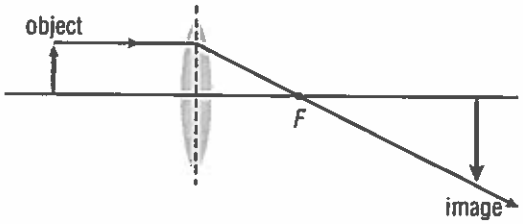
(iii) larger than the object, upright, located on same side, virtual



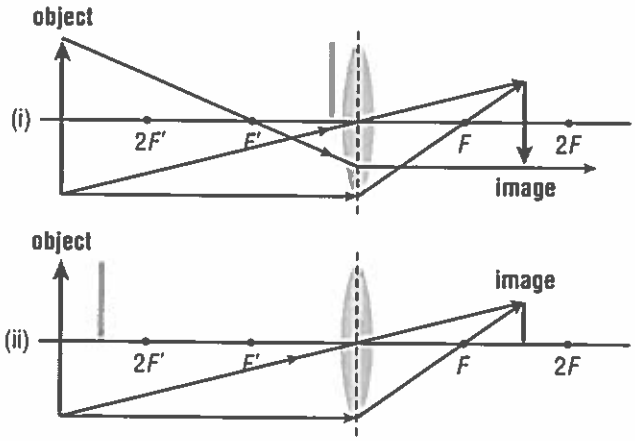
(iv) smaller than the object, upright, located on the same side, virtual



3. A ray from the object arrow tip going parallel to the principal axis will refract through *F* and pass through the image of the arrow tip. This ray crosses the principal axis at *F*.

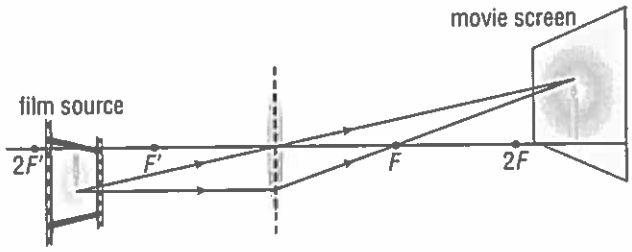


4. **(a)** and **(b)**



5. A real image is never formed because the emergent rays from a divergent lens always spread apart. A real image can only be formed if the emergent refracted rays cross or converge. The human brain interprets diverging light from this type of lens as if it were coming from a single focus point, creating a virtual image.
6. The size of the virtual images produced by a converging mirror changes depending on the distance of the object. An image produced by a diverging mirror never changes in size. A converging lens produces a larger-than-life virtual image, and a diverging lens produces a smaller-than-life virtual image.
7. If a lens produces a virtual image, it will be upright and located on the same side of the lens as the object. A real image is produced if the orientation of the image is inverted to that of the original object.
8. **(a)** A converging lens—a real image is produced on the screen.

   (b) The diagram should show the object (the film) below the principal axis, located between $2F'$ and F', so that an enlarged, right side up image is produced.



   (c) The image is larger than life, inverted, beyond $2F$, and real; for the image to appear right side up, the film must be inserted in the projector upside down.

DIFFERENTIATED INSTRUCTION

- Encourage visual/spatial students to create a poster for the class showing the information in Table 1 on page 559 of the Student Book with diagrams, as well as information on diverging lenses. Encourage students to refer to the table as they go over different situations in this section and other sections of the chapter.
- Bodily/kinesthetic learners should benefit from returning to the lens, candle, and screen set-up of the previous section's activity. Allow students to conduct the same experiment as before, but this time using the illustrations and descriptions contained in this section. Students should try to duplicate the images and demonstrate the different movements and relocation of the light, explaining as they do the experiments how the principles of refraction are producing what they see.

ENGLISH LANGUAGE LEARNERS

- Pair students with widely varied comprehension, vocabulary, or fluency strengths. Have students model reading for each other. Students can work to define terminology in their own words and guide each other through their reading.

Business Studies Connections

Encourage students to research developments and innovations related to lenses and how those changes have affected people's lives. Have them relate these developments to demand in the market and the efforts of entrepreneurs and established companies to meet these demands. For example, have them consider the evolution of the camera.