Calculate the magnification of an object placed 6.20 mm from a compound microscope that has a 6.00 mm focal length objective and a 50.0 mm focal length eyepiece. The objective and eyepiece are separated by 23.0 cm.

**Strategy and Concept**

This situation is similar to that shown in Figure 2. To find the overall magnification, we must find the magnification of the objective, then the magnification of the eyepiece. This involves using the thin lens equation.

**Solution**

The magnification of the objective lens is given as

mo=−di/do

where *d*o and *d*i are the object and image distances, respectively, for the objective lens as labeled in Figure 2. The object distance is given to be *d*o=6.20 mm, but the image distance *d*i is not known. Isolating *d*i, we have

1/di=1/fo−1/do

where *f*o is the focal length of the objective lens. Substituting known values gives

1/di=16.00 mm−16.20 mm=0.00538mm.

We invert this to find *d*i: *d*i= 186 mm.

Substituting this into the expression for *m*o gives

mo=−di/do=−186 mm/6.20 mm=−30.0.

Now we must find the magnification of the eyepiece, which is given by

me=−di′/do′

where *d*i′ and *d*o′ are the image and object distances for the eyepiece (see Figure 2). The object distance is the distance of the first image from the eyepiece. Since the first image is 186 mm to the right of the objective and the eyepiece is 230 mm to the right of the objective, the object distance is *d*o′ = 230 mm − 186 mm = 44.0 mm. This places the first image closer to the eyepiece than its focal length, so that the eyepiece will form a case 2 image as shown in the figure. We still need to find the location of the final image *d*i′ in order to find the magnification. This is done as before to obtain a value for 1/di′:

1/di′=1/fe−1/do′=150.0 mm−144.0 mm=0.00273mm

Inverting gives

di′=−mm0.00273=−367 mm.

The eyepiece’s magnification is thus

me=−di′/do′=−(−367 mm/44.0 mm)=8.33.

So the overall magnification is *m*= *m*o*m*e = (−30.0)(8.33) = −250.

**Discussion**

Both the objective and the eyepiece contribute to the overall magnification, which is large and negative, consistent with Figure 2, where the image is seen to be large and inverted. In this case, the image is virtual and inverted, which cannot happen for a single element (case 2 and case 3 images for single elements are virtual and upright). The final image is 367 mm (0.367 m) to the left of the eyepiece. Had the eyepiece been placed farther from the objective, it could have formed a case 1 image to the right. Such an image could be projected on a screen, but it would be behind the head of the person in the figure and not appropriate for direct viewing. The procedure used to solve this example is applicable in any multiple-element system. Each element is treated in turn, with each forming an image that becomes the object for the next element. The process is not more difficult than for single lenses or mirrors, only lengthier.