One sort of yard 'art' that you occasionally see consists of a polished metal sphere of some color mounted on a pedestal. Suppose we have such a sphere with a **diameter** of 60 $cm$. A 10 $cm$ tall bird is hovering at a distance of 20 $cm$ from the mirrored surface.

object      mirror

Determine the focal length of the mirror and the location, size, orientation, and nature (real or virtual) of the image of the bird that the mirrored surface will form. (Be sure to explain/justify your sign choices in setting this up and all your answers.)

(a) Focal length: ———————— $cm$
     Image location: ———————— $cm$ to the LEFT or RIGHT (pick one) of the mirror.
     Image size: ———————— $cm$
     Image orientation: UPRIGHT or INVERTED?
     Is the image REAL or VIRTUAL?

(b) Sketch a decent ray diagram for this scenario (See the special instructions for ray diagrams on the first page of the test.)

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**Focal length :** $\boxed{-15\ cm}$
Mirror: $f = R/2$. Here the radius is half the diameter, so $|R| = 30\ cm$. The center of curvature is NOT on the same side of the mirror as the rays (either incoming or outgoing, since they're both on the same side in the case of a mirror), making $R = -30\ cm$ here. Thus: $f = R/2 = (-30\ cm)/2 = -15\ cm$.

**Image location :** $\boxed{8.57\ cm}$ to the $\boxed{\text{RIGHT}}$ (left or right?) of the mirror. (Note: that is, relative to left side of the mirrored ball: the side the bird is near. Be sure to explain your choice.)
The object is 20 $cm$ from the mirror, on the same side as the rays incoming to the mirror, so $d_o = +20\ cm$. $d_i = \frac{d_o f}{d_o - f}$, so $d_i = \frac{(+20)(-15)}{(+20)-(-15)} = (-300)/(35) = -8.57\ cm$. The sign implies that the image is NOT on the outgoing ray side (which would be to the left here), so the image is forming 8.57 $cm$ 'inside' (to the right) of the polished surface.

**Image height** (including sign): $\boxed{+4.2857\ cm}$
$m = h_i/h_o = -d_i/d_o = -(-8.57)/(20) = +0.42857$ so $h_i = mh_o = (0.42857..)(10\ cm) = +4.2857\ cm$.

**Orientation :** $\boxed{\text{upright}}$ or inverted? (**explain**)
$m$ is positive; or the image height is positive, implying an upright image.

**Nature :** real or $\boxed{\text{virtual}}$? (**explain**)
The image is NOT on the outgoing ray side, making the image virtual.

**Ray Diagram**

- Ray 1: heading along a radial (i.e. to C), bounces back along same path

- Ray 2: parallel to axis, reflects as if from F

- Ray 3: ray to vertex bounces off at same angle

- Ray 4 (not drawn) : a ray heading towards F would bounce back parallel to the axis

obj

image

F    C