Due Feb. 19, Thursday

All problems must be solved symbolically first. Then, any numerical answer, when required, can be computed by substituting numbers into the symbolic expression at/near the very end. Solving problems symbolically means deriving the answer in terms of symbols, instead of numerical values. All problem numbers refer to those in the textbook. (Not all problems may be graded in detail, due to limited man power; however, you must do all problems.)

For each problem, you are required to use sensible symbols, by defining or adopting them yourself, for your symbolic solution. If you are unsure how to do so, feel free to ask (or look back at homework 1)!

Problem 1 (10 points) Problem 32.4 (plane mirror).

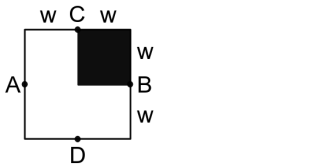
Problem 2 (10 points) Problem 32.5 (plane mirrors).

Problem 3 (10 points) Problem 32.13 (spherical mirror).

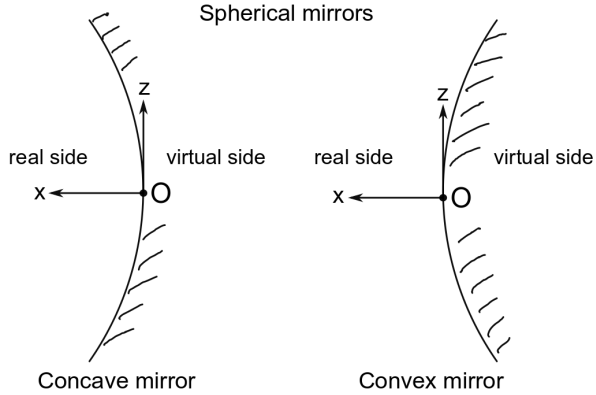
Problem 4 (10 points) Problem 32.15 (spherical mirror).

Problem 5 (10 points) Problem 32.20 (concave mirror).

Problem 6 (30 points) Consider a small object, which is a thin square cardboard ($2w \times 2w$) with one quarter painted black, as shown below. This object is imaged by a concave spherical mirror or a convex spherical mirror. For each mirror, we take the coordinate system such that the origin (O) lies at the mirror, and the xyz coordinate system is defined as shown below (we use the right handed coordinate system, which means that the y axis points out of paper towards us).



Object (a square cardboard)
width = 2w, height = 2w
Scale, position, and orientation, relative to mirror, are not correctly represented here. Read the text for correct information.



(a) Consider a concave mirror with r = 100.0 cm. If $A = (d_o, w, 0)$, $B = (d_o, -w, 0)$, $C = (d_o, 0, w)$, with d_o = 40.0 cm and w = 0.5 cm, where is the image of the square? To answer this, it suffices to find where points A, B, C, D are imaged, since the square is small.

(b) Just like the previous part, except d_o = 80.0 cm.

(c) Just like the previous part, except d_o = 120.0 cm.

(d) Just like the previous part, except the mirror is a convex mirror.

(e) Consider a concave mirror with r = 100.0 cm. If $A = (d_o, w, 0)$, $B = (d_o, -w, 0)$, $C = (d_o + w, 0, 0)$, with d_o = 40.0 cm and w = 0.5 cm, where is the image of the square? To answer this, it suffices to find where points A, B, C, D are imaged, since the square is small.

(f) Just like the previous part, except d_o = 80.0 cm.

(g) Just like the previous part, except d_o = 120.0 cm.

(h) Just like the previous part, except the mirror is a convex mirror.

(i) Prove in general that, for a short line segment that lies on the x axis, the magnification, i.e., the *longitudinal* magnification, is given by $-m^2$, where $m = -d_i/d_o$ is the lateral magnification. [Hint: stare at the mirror equation and then take the derivative.]

Problem 7 (10 points) Problem 32.42 (reflection and refraction).

Problem 8 (10 points) Problem 32.47 (Snell's law and beam shape), **modified as follows:** let us assume that the beam in air has a circular cross section, (a) what is the shape of the cross section after the beam has entered the glass, (b) what are the dimensions of the cross section, and (c) what is the ratio of the two cross sectional areas, one for beam in air and the other for beam in glass?