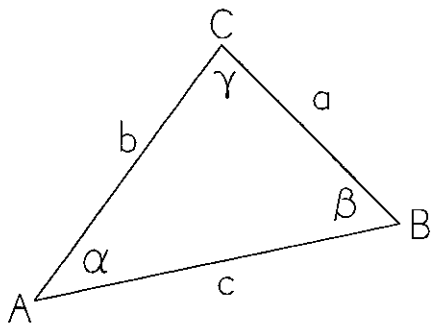
# Review 8 — Geometry I - Describing and Drawing

Geometry literally means "measuring the earth", but it has come to mean much more than ways to calculate the area of a farmer's field. This venerable subject is applicable even to the most modern problems. Setting up problems for solution often demands both a familiarity with the nomenclature of geometry and an ability to readily translate geometrical description into useful drawings. The basic ideas required are covered in this review.

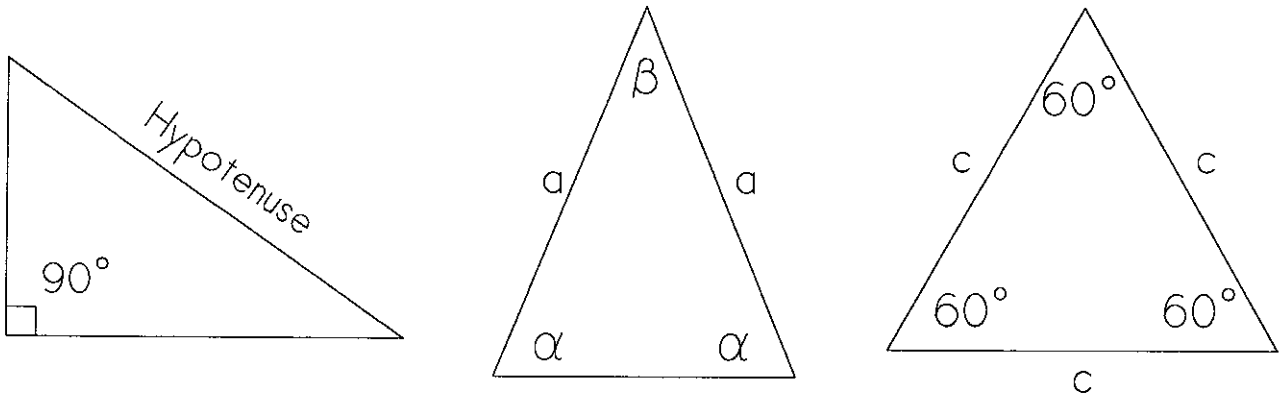
## PLANE FIGURES

**Two dimensions.** Although the objects of physics are obviously located in three-dimensional space of up-down, front-back, and side-to-side, much of what goes on is confined to two dimensions: the cables supporting an object from a derrick lie in a plane; planets move in flat orbits. Moreover, since the drawings we make are forced into the two dimensions of a sheet of paper or a chalkboard we need to think easily about the silhouettes and cross-sections which represent a problem. The common plane figures described in this section recur over and over in physics problems.

**Triangles.** The three straight lines forming this simplest of polygons must by necessity all lie in the same plane. Each corner of the triangle is called a *vertex*. It is commonplace to label the three angles by Greek letters and the sides opposite those angles by corresponding Roman letters.




**Special triangles.** Of particular importance in physics problems are *right* triangles, *isosceles* triangles, and *equilateral* triangles. An example of each is shown here.



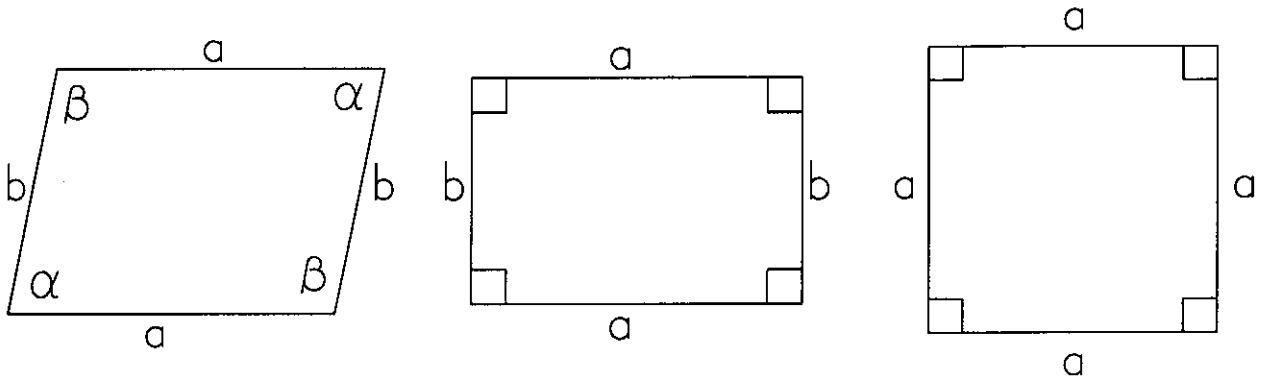

Basic properties of these triangles are as follows:

- *A right triangle contains a <u>right</u> angle (90°) opposite the side labeled the <u>hypotenuse</u>.*

• *An isosceles triangle has two equal angles (α). These are opposite two equal sides (a) which converge at the apex of the triangle. The side opposite the apex angle β is the base of the isosceles triangle.*

• *An equilateral triangle is completely symmetric. All sides are of equal length and all angles are equal to 60°.*

**Four sided plane figures (quadrilaterals).** Of these, we mostly need to know about regular figures with pairs of parallel sides. Shown here are a *parallelogram*, a *rectangle*, and a *square*:



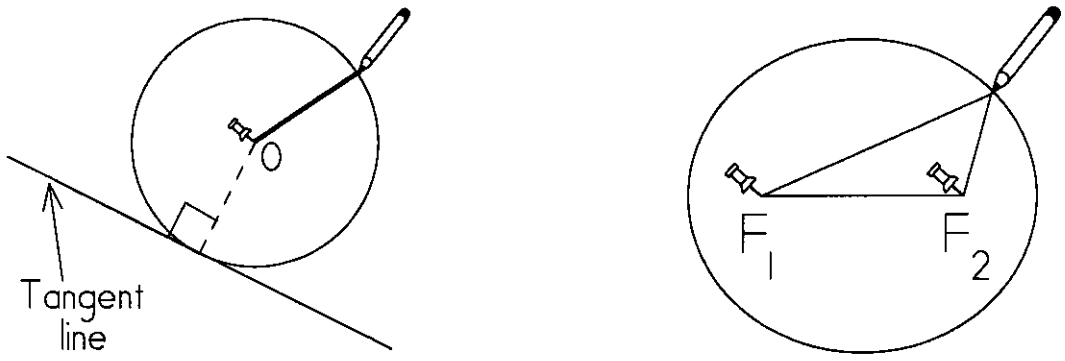

• *A parallelogram has pairs of equal angles (α and β) and opposite pairs of equal sides (a and b). Opposite sides are parallel.*

• *A rectangle is a parallelogram with all right angles.*

• *A square is a rectangle having four equal sides.*

**Circles and ellipses.** Circles crop up frequently in physics problems; ellipses occur less often. The drawings below are a reminder of how these figures can be formed by scribing a line inside a loop of string stretched out around a single fixed *center* (circle) or around two fixed *foci* (ellipse). Also shown is a line tangent to the circle, a straight line which touches at only one point.

• *A tangent line is perpendicular to a radius at the point of contact.*



**Making useful sketches.** Some of the previous Reviews have stressed the importance of sketch-making in solving problems. The language and facts of geometry facilitate the art of making truly useful drawings. A ruler, compass, and protractor are usually not necessary; a reasonably careful freehand sketch is good enough most of the time.

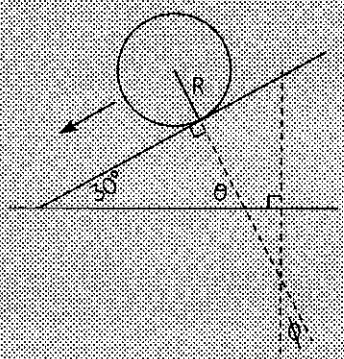
- *A "careful" drawing is not a masterpiece; but it should not mislead.*

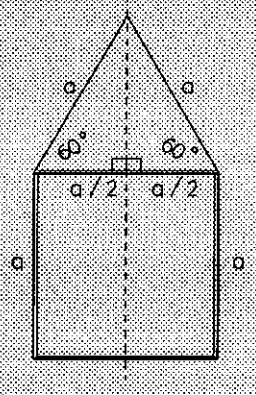
For instance, when a circle is specified it should not look a lot like an ellipse; by the same token if an angle is *not* specified it should not appear to be a right angle. Simple aids to the memory are often used, such as an arrow to represent a direction of motion. Here are a couple of examples of word descriptions translated into serviceable drawings.

Make sketches representing the following situations:

(a) A circular hoop rolling down a plane inclined at 30° to the horizontal; and

(b) a square picture with sides of length a supported evenly from two corners by a string of total length 3a passing over a hook in the wall.



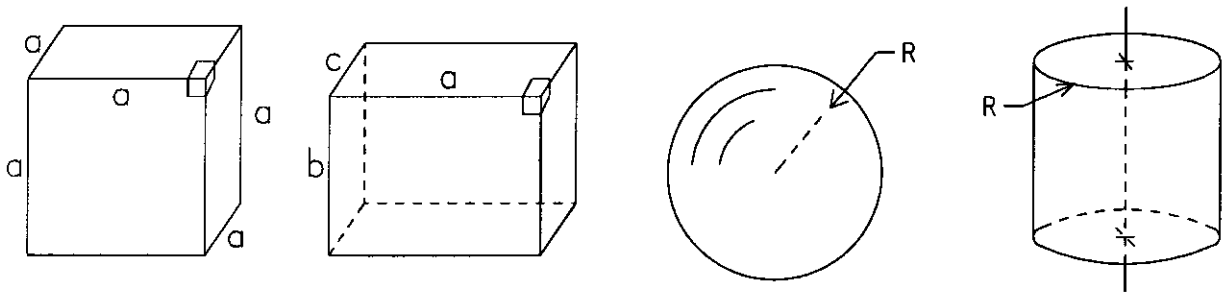

DISCUSSION: Some features which might be crucial to solving a problem have been included in the drawings for discussion.

(a) The plane is tangent to the hoop, hence the plane is perpendicular to the radius R. The plane lies on the hypotenuse of a right triangle with vertical and horizontal sides. An extension of the radius meets the horizontal at angle θ and the vertical at angle φ.

(b) The string and upper edge of the picture form an equilateral triangle with sides a. A vertical line through the hook divides this triangle into right triangles and divides the picture into rectangles with sides a and ½ a.

## SOLID FIGURES

**Important shapes.** At the beginning level in physics there are a few 3-dimensional shapes which the student has to think about. Some common ones are the cube, rectangular parallelepiped, sphere, and right circular cylinder. To keep an illusion of three dimensions they can be sketched "in perspective" as shown here.




Here are some useful things to remember about these objects:

The rectangular parallelepiped is a figure formed from 6 rectangles joined by their edges; all the edges join at right angles. A cube is a rectangular parallelepiped formed from identical squares. The right circular cylinder can be thought of either as being generated by sliding a circle along its axis, or by wrapping an originally flat sheet around two identical parallel circular disks.

**Drawing solid shapes.** Notice some of the special touches which make the drawings above "believable". Right angle symbols emphasize the relationship of the lines at each corner of the cube and parallelepiped; dashed lines are used for hidden edges. Notice how a few contour lines can be used to distinguish a sphere from a circle. The "end caps" of the cylinder are drawn elliptical, which is how a circle appears when viewed off-axis.

With a little practice you should not find it difficult to make rough approximations of these drawings for yourself. Most problems in physics will probably not require such pictures, but occasionally making a "3-dimensional" perspective sketch can stimulate your thinking about a problem. Consider, for instance, the following example:

Identical atoms lie at each corner of a cube with sides of length a. Draw the line which joins two diagonally opposite atoms.