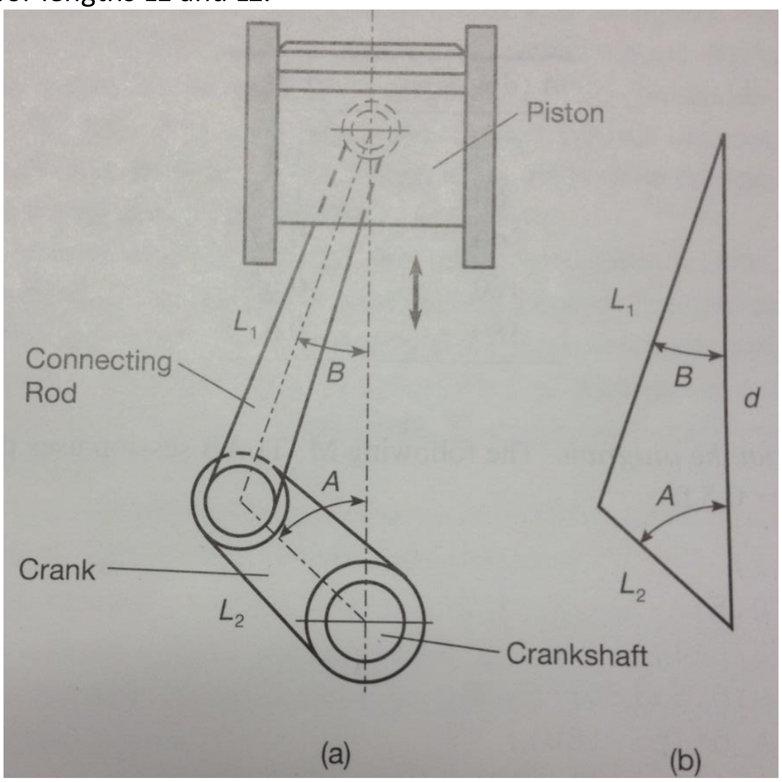
1. Identify the variable to solve for in the following problem statements:
   a. The air pressure and density at a point on the wing of a Boeing 747 are 1.10×10^5 N/m and 1.2 kg/m^3, respectively. What is the temperature at that point?
   The variable to solve for is the temperature at the point on the wing of interest.
   b. An ordinary, helium-filled party balloon has a volume of 2.2 ft^3. The lifting force on the balloon due to the outside air is the net result of the pressure distribution exerted on the exterior surface of the balloon. Assuming the balloon is at sea level, can a pencil tied to the string be lifted?
   The variable to be solved for is the lifting force on the balloon. This should then be compared to the weight of the pencil (mass of the pencil multiplied by the acceleration due to gravity) to determine if the pencil can be lifted.
2. A piston, connecting rod, and crank for an internal combustion engine is shown in the figure below. When combustion occurs, it pushes the piston down. This motion causes the connecting rod to turn the crank shaft. Use the Problem Solving Method to develop the equations that will allow us to compute the distance from the crankshaft center, d, traveled by the piston as a function of the angle A, for given values of lengths L1 and L2. Such equations would help engineers when designing the engine to select appropriate values for lengths L1 and L2.



1. The purpose of the problem is to design the lengths of the connecting rod (L1) and crank (L2) in the engine.
2. We know the connecting rod is fixed to the piston on one side and the crank on the other. We know the crank is connected to the connecting rod on one side and the crankshaft on the other.

3. We are required to find the equations to allow us to compute the distance from the crankshaft center (d) traveled by the piston as a function of the angle A, for given lengths L1 and L2.
4. We assume the connecting rode and crank are simple linear (1D) components. We assume they are connected at one point (no size to the connections). We assume component can only move in one plane. We assume no parts will break or structurally deform.
5. The figure above is a good drawing of the problem with appropriate labels.
6. Geometry of triangles can be applied. Specifically the cosine rule can be applied:

$$a^2 = b^2 + c^2 - 2bc\cos(A)$$

Solving this may require finding the root of a quadratic equation. This could be done with the quadratic formula:

$$X = -b \pm \sqrt{b^2 - 4ac} / (2a) \text{ for } aX^2+bX+c = 0$$

7. Instead of the quadratic formula, a numerical root finding approach could be used (such as the bisection method). A numerical simulation of the motion path could be done.
8. Define the sides and angles. Apply the cosine rule. Solve for d as a function of L1, L2, and A.

$$L1^2 = d^2 + L2^2 - 2 \cdot d \cdot L2 \cdot \cos(A)$$

$$0 = d^2 - 2 \cdot L2 \cdot \cos(A) \cdot d + (L2^2 - L1^2)$$

$$d = [2 \cdot L2 \cdot \cos(A) + \sqrt{4 \cdot L2^2 \cdot \cos^2(A) - 4 \cdot 1 \cdot (L2^2 - L1^2)}] / 2 \cdot 1$$

9. As a simple version, what if A = 0? Hopefully d = L1+L2. Let's check:

$$\cos(0) = 1$$

$$d(A=0) = [2 \cdot L2 \cdot 1 + \sqrt{4 \cdot L2^2 \cdot 1 - 4 \cdot 1 \cdot (L2^2 - L1^2)}] / 2$$

$$d(A=0) = [2 \cdot L2 + \sqrt{4 \cdot L2^2 - 4 \cdot L2^2 + 4 \cdot L1^2}] / 2$$

$$d(A=0) = [2 \cdot L2 + \sqrt{4 \cdot L1^2}] / 2$$

$$d(A=0) = [2 \cdot L2 + 2 \cdot L1] / 2$$

$$d(A=0) = L2 + L1 \qquad \text{check!}$$

10. Reality check: d must be a real number. It should be no larger than L1+L2. It should be no smaller than L1 – L2.

3. Draw a flowchart for the following problem: A planetary lander controls its engine thrust. It tilts to control its horizontal position, which is provided as a function of time (t, θ). The thrust remains aligned with the vehicle (no rocket gimbal). Plot the thrust required to maintain a constant descent rate (no vertical acceleration) at each time point t_i. If the instantaneous thrust exceeds T_{max}, display a warning and stop. The landing could happen on the moon (g=0.16G) or Mars (g=0.38G)