Working in a group of 2–3 people, complete at least 1 of the following problems. After 50 minutes have elapsed, submit your solutions to your workshop instructors. You should be able to do the other problems—use them for practice!

Your group’s work will be graded on correctness, but more of your grade will depend on communication. Consider workshops as practice for your written assignments. Writing legibly (including well-labelled graphs), using complete sentences, and fully explaining your thoughts in a logical order will earn high marks.

In your solution, follow the steps: draw a picture if possible; write down what you are given; write down what you want to find; write down an equation relating these; reduce this equation to one variable if necessary; differentiate with respect to time using the Chain Rule; and solve and do a reality check.

1. Boyle’s Law. In chemistry, Boyle’s Law describes the behaviour of an ideal gas: this law relates the volume \( V \) occupied by the gas to the temperature \( T \) and the pressure \( P \) as follows:

\[
PV = nRT
\]

where \( n \) and \( R \) are positive constants.

(a) Suppose that pressure is kept fixed by allowing the gas to expand as the temperature is increased. Relate the rate of change of volume to the rate of change of temperature.

(b) Suppose that the temperature is held fixed and the pressure is decreased gradually. Relate the rate of change of the volume to the rate of change of pressure.

2. Gas is being pumped into a spherical balloon at the rate of 3 cm\(^3\)/s.

(a) How fast is the radius increasing when the radius is 15 cm?

(b) Without using the result from (a), find the rate at which the surface area of the balloon is increasing when the radius is 15 cm.

3. A company that produces landscaping materials is dumping sand into a conical pile. The sand is being poured at a rate of 5 ft\(^3\)/s; the physical properties of the sand, in conjunction with gravity, ensure that the cone’s height is 2/3 the length of the diameter of the circular base. How fast is the cone rising when it has a height of 30 feet?

4. Radar guns measure the rate of distance change between the gun and the object it is measuring. For instance, a reading of 55 kmh means the object is moving away from the gun at a rate of 55 kmh, whereas a measurement of \(-25\) kmh would mean that the object is approaching the gun at a rate of 25 kmh. Suppose an officer is driving due north at 30 kmh, and sees a car moving due east. Using a radar gun, the officer measures a reading of 20 kmh. By using landmarks, the cars are estimated to each be 1/2 km from the intersection of their two roads. If the speed limit on the other road is 50 kmh, is the other driver speeding?

After you finish these problems, please submit your work to your workshop instructors. In the remaining 30 minutes of workshop, make the most of the available time and help.