1. **Space Shuttle** – *Have student work in group, then have a class discussion.*

   At the Kennedy Space Center, the VIP site for launch viewing (where the camera is located) is 3.9 miles away form pad 39A (where the shuttle is launched) [1].
   According to NASA [2], during the first stage ascent, the shuttle reaches the speed of 4,828 kph within 2 minutes or an average speed of 2,414 kph.

   Using this information, compute how fast the angle that the camera makes with the horizontal increases.

   - *Have students form groups of 2-4. Have them compare their sketches from the pre-class activity. Have them also compare their lists of the information one needs to solve this problem.*
   - *Quickly go around the room to see the sketches of the students.*
   - *Using students' input, either ask one/several student(s) to draw their sketches and/or equations on the board (you can do this while the students work in group and you go around the room) or use their input to draw a proper sketch on the board and give the equation relating the angle and the height of the shuttle. Then, take the derivative, the variation of the angle and the speed of the shuttle. This part constitute a sort of worked example for the students.*
   - *What simplification are we making here? – We assume the velocity of the space shuttle is constant.*

   Now that we have solved this exercise, identify the steps we have taken to solve it.
   You can do a think-pair-share if time allows

   For the following two activities (on the following pages), you can create a jigsaw where each expert group work on its problem up to e) (before the numerical application). Then pair up students and give them the numerical applications part.
   Or just have students work in groups on the two problems (without more directions).

[1] cf. http://www.launchphotography.com/Delta_4_Atlas_5_Falcon_9_Launch_Viewing.html
[2] cf. https://spaceflight.nasa.gov/shuttle/reference/basics/launch.html

2. **In-car Speed Camera**
An undercover police car equipped with an in-car speed camera is driving along a road toward an intersection. A car is driving on the perpendicular road passing directly in front of the police car. The speed camera measures the speed at which the car is driving away from the police car. We want to determine the actual speed of the car.

   a) Draw a sketch of the situation. What assumptions are we making here? *The roads are straight lines*

   b) Determine what the variables are. In terms of your variables, what are we trying to determine? And what does the speed camera measure?

   c) Find and equation that relates your variables.

   d) Taking the derivative, find an equation that relates the speed of the police car, the speed of the car and the speed measured by the speed camera.

   e) To determine the speed of the car, what information do we need?

   f) When the speed camera takes its measurement, the police car is 30 meters away from the intersection and drives at a speed of 20 kph. At that moment, the car is 40 meters away from the intersection. The speed measured by the speed camera is 50 kph. What is the speed of the car?

3. **Blowing a balloon** *Do take an actual balloon in class and start with a demonstration!*
You are preparing the birthday party of your 5-year old cousin. An essential element is of course to have balloons all around the room!
You use a pump (or your lungs), for which we know the output, to blow the balloons. We want to compute how fast the radius of a balloon increases as we blow it.

   a) Draw a sketch of the situation. What assumptions are we making here? *Balloons are perfect spheres*

   b) What are the variables and what are the constants?

   c) In terms of the variables you have defined, what are we looking for?

   d) To determine the speed at which the radius increases, what information do we need?

   e) Using the fact that the volume V of a sphere is $V = \frac{4}{3}\pi r^3$, relate the variables by an equation. Then taking the derivative, find an equation that related the rate of change of the volume of a balloon and the rate of change of its radius.

   f) If the pump you are using (or you lungs!) has an output of 50π cm^3/s, how fast is the radius increasing when the radius of the balloon is 5 cm.

4. **Connecting Rods – Challenge Exercise**
Connecting rods are used in internal combustion engines (i.e. most of today's car engines) or formerly in steam engines. Their role is to transform a linear movement into a circular one. For an illustration or this mechanism see https://upload.wikimedia.org/wikipedia/commons/0/01/Slider_Crank_animation.svg and https://en.wikipedia.org/wiki/Crankshaft#/media/File:Cshaft.gif.[3]
Our goal for this exercise is to determine how the linear and circular velocities are related.

   a) Draw a sketch of the situation. What is constant and what is variable?

   b) Find an equation that relates the angular velocity of the crankpin (the part that has a circular motion) to the velocity of the piston (the part of the crankshaft that moves on the horizontal axis).

      You will probably need to use the law of sines $\dfrac{a}{\sin\alpha} = \dfrac{b}{\sin\beta} = \dfrac{c}{\sin\gamma}$ and the law of cosines $c^2 = a^2 + b^2 - 2ab\cos\gamma$. [4]

   c) If the radius of the circle around which the crankpin is moving is 5cm and the length of the connecting rod 15cm, at what speed is the piston moving in cm/s if the crankpin is moving at 2000 round per minute?

[3]For more on this, look at https://en.wikipedia.org/wiki/Crankshaft or https://en.wikipedia.org/wiki/Internal_combustion_engine.

[4]More detail on Wikipedia: https:en.wikipedia.org/wiki/Law_of_sines and https://en.wikipedia.org/wiki/Law_of_cosines.