

9. [7 points] Emily is transporting a chocolate ice cream cone up 1 story of East Hall to her friend. However, there is a hole in the bottom of the cone and ice cream drips out in a steady stream.

The mass of the cone is 200 grams and there are initially 100 grams of ice cream in the cone. The ice cream drips out at a rate of 4 grams/sec. Emily spends 10 seconds raising the cone at a constant rate of 0.5 m/sec to reach her friend.

- a. [3 points] What is the total mass in grams of the cone and the ice cream in the cone when Emily has lifted it a vertical distance  $\ell$  m?

*Solution:* When Emily has lifted the cone a vertical distance of  $\ell$  m, she has lifted for  $2\ell$  sec. Therefore,  $8\ell$  grams of ice cream has dripped out of the cone. The cone and ice cream start at 300 grams.

$$\text{Mass} = \frac{300 - 8\ell}{\quad} \text{ grams}$$

- b. [4 points] Write, but do not evaluate, an integral that represents the total amount of work (in grams  $\text{m}^2/\text{sec}^2$ ) done by Emily lifting the cone filled while the ice cream drips. You may assume the acceleration due to gravity is  $g = 9.8 \text{ m}/\text{sec}^2$ .

*Solution:* The work to lift the rocket between  $\ell$  and  $\ell + \Delta\ell$  m is

$$\Delta W = 9.8(300 - 8\ell)\Delta\ell.$$

Hence, the total work is below.

$$\text{Work} = \frac{\int_0^5 9.8(300 - 8\ell)d\ell}{\quad} \text{ grams } \text{m}^2/\text{sec}^2$$