

Homework 1

(I) I left a cylindrical bucket outside on the drive way in the rain. The radius of the bucket is 20 centimeters. When I picket up the bucket after 50 minutes there was 15 millimeters of rain water accumulated at the bottom. I estimated the diameter of the raindrops to be about 3 millimeters.

(a) [15 pts.] Find a symbolic expression for the number of raindrops that fell per unit area and per unit time while the bucket was out (Do not forget to carefully define each of the variables you use in your work.).

(b) [5 pts.] How does your response depend on the diameter of the bucket?

(c) [10 pts.] Provide a numerical value for the number of raindrops that fell per unit area and per unit time. Give your result as a number of drops per square-meters (m^2) and per seconds (s) so your result should be a number of "drops $\cdot \text{m}^{-2} \cdot \text{s}^{-1}$ ".

(II) I have another cylindrical bucket 20 centimeters in radius. This bucket leaks because I drilled a circular hole 3 millimeter in diameter in the bottom. When the bucket is full of fluid, it takes 15 seconds for the level of fluid in the bucket to drop by 1 centimeter.

(a) [15 pts.] Find a symbolic expression for the speed at which the fluid is flowing through the hole at the bottom of the bucket (Do not forget to carefully define each of the variables you use in your work.).

(b) [5 pts.] Obtain a numerical value for the speed at which the fluid is flowing through the hole at the bottom of the bucket. Give your answer in meters per seconds ($\text{m} \cdot \text{s}^{-1}$)

(III) Unit conversions

(a) [10 pts.] In the International System of units, a pressure is given in Newtons (N) per square-meters (m^{-2}) that is in $\text{N} \cdot \text{m}^2$ (which is also known as a Pascal Pa). In the Imperial System of units, pressure is given in pounds (lb)per square inch (in^2) that is $\text{lb} \cdot \text{in}^{-2}$ which we commonly refer to as "PSI". I inflate the tires of my bicycle to a pressure of 90 PSI. Knowing that one pound is worth 4.4482 Newtons and that one inch is worth 25.4 millimeters, find my bicycle tire pressure in Pascals.

- (b) *[10 pts.]* In the International System of units, an energy is given in Newtons (N) times meters (m) that is $N \cdot m$ (which is also known as a Joule J). In the Imperial System of units, an energy is given in foot (ft) times pound (lb) or $ft \cdot lb$ which we commonly referred to as foot-pound. Knowing that one pound is worth 4.4482 Newtons and that there is 0.3048 meters in a foot, find many foot-pounds there are in a Joule.
- (c) *[10 pts.]* My car's gas mileage is 30 miles per gallon. In Europe people describe their car's efficiency as a number of liters required to travel 100 kilometers. Knowing that there are 4.54609 liters in a gallon and that a mile is worth 1.6093 kilometers, find the efficiency of my car expressed the European way.
- (IV) *[20 pts.]* The Sun illuminates the Earth with an energy flux of about 1400 Joules per second per square meter that is $1400 \text{ J} \cdot \text{s}^{-1} \cdot \text{m}^{-2}$. The luminous energy is delivered in quanta known as photons. Each photon as an energy of about 10^{-19} J . In bright light, the human eye pupil is about 1.5 millimeters in diameter. When we accidentally look at the Sun without protection we have the reflex to close our eyes very quickly. This takes of the order of 0.1 second. In that time, how many photons enter one of our eyes?