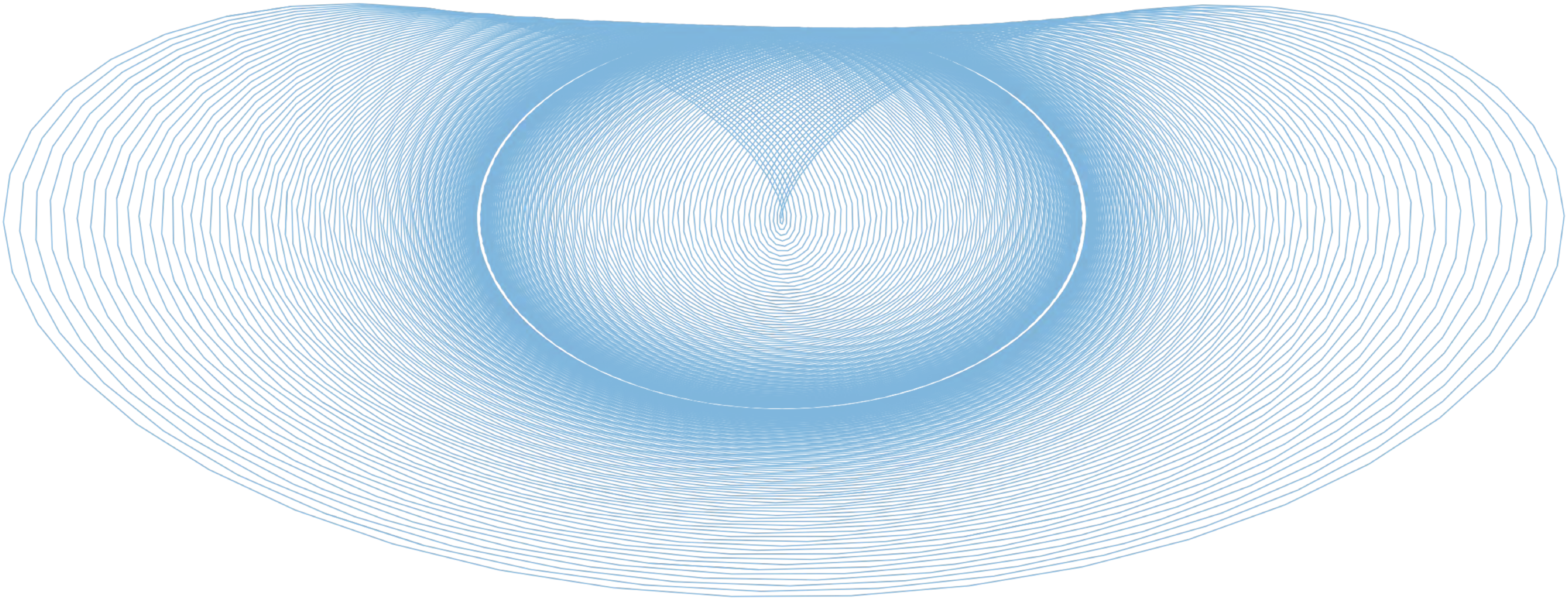
PHYS 1420 (F19)
Physics with Applications to Life Sciences



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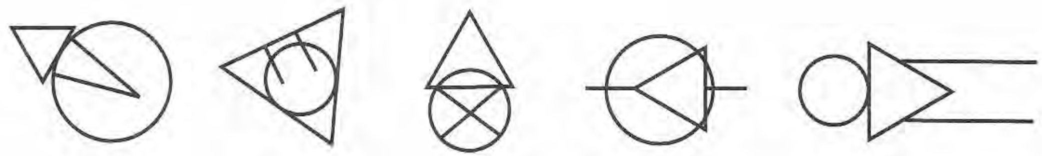
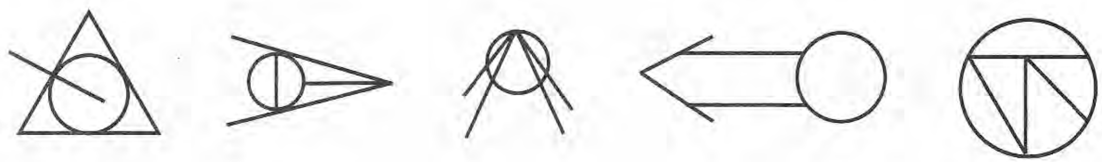
2019.11.19 (Tutorial)

Jollos and Plotz

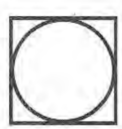
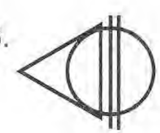
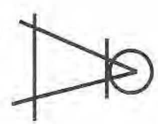
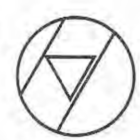
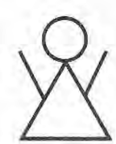
These are jollos:



These are plotz:



Which are jollos and which are plotz?

A.  B.  C.  D.  E. 

THE YORKU BIOPHYSICS CLUB PRESENTS
IN PARTNERSHIP WITH DR. PETER BACKX

FROM STEM CELLS TO ARRHYTHMIA

YORK U BIOPHYSICS CLUB

A LECTURE ON USING TISSUES GENERATED FROM STEM CELLS TO BETTER-UNDERSTAND CARDIAC ARRHYTHMIAS

THURSDAY, NOVEMBER 21ST
5:30-7:00PM
REFRESHMENTS PROVIDED

PETRIE SCIENCE & ENGINEERING BUILDING
RM 317

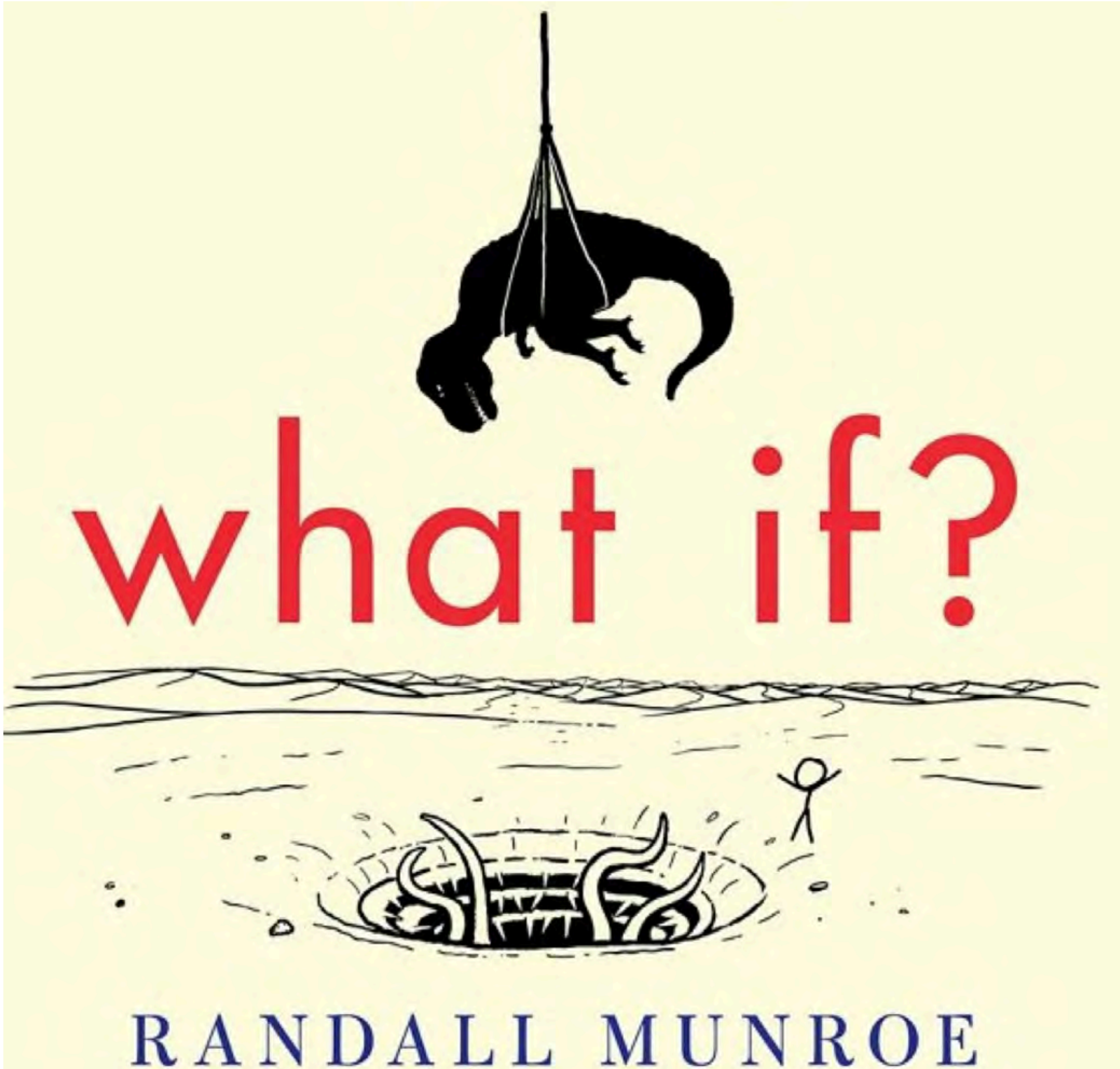
1. (*20 points*) A ball is thrown vertically upward from the ground with speed v_o m/s.

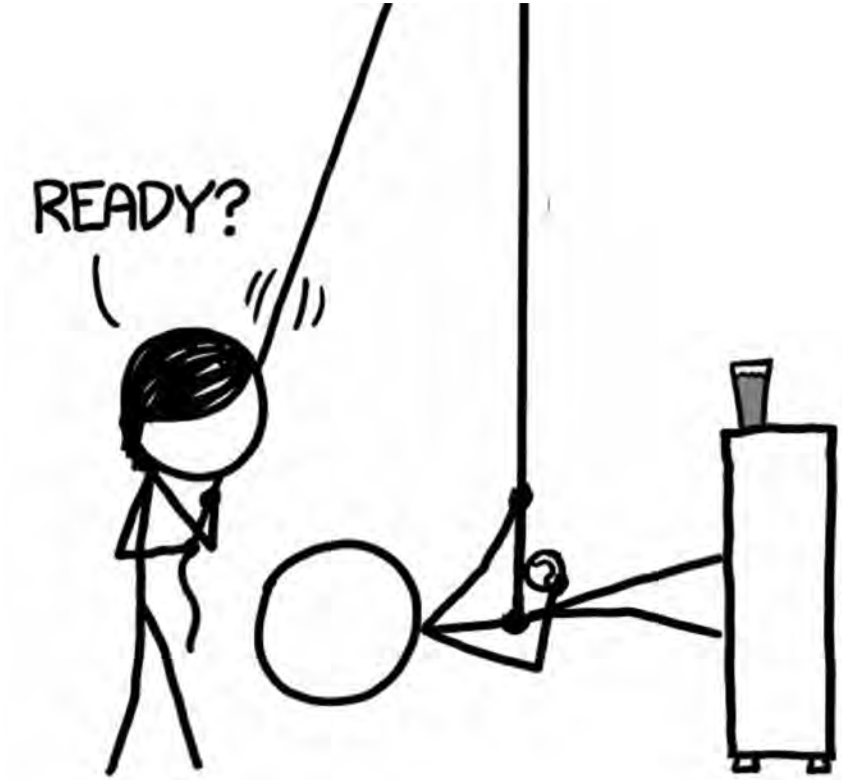
a. How long does it take to reach its highest point?

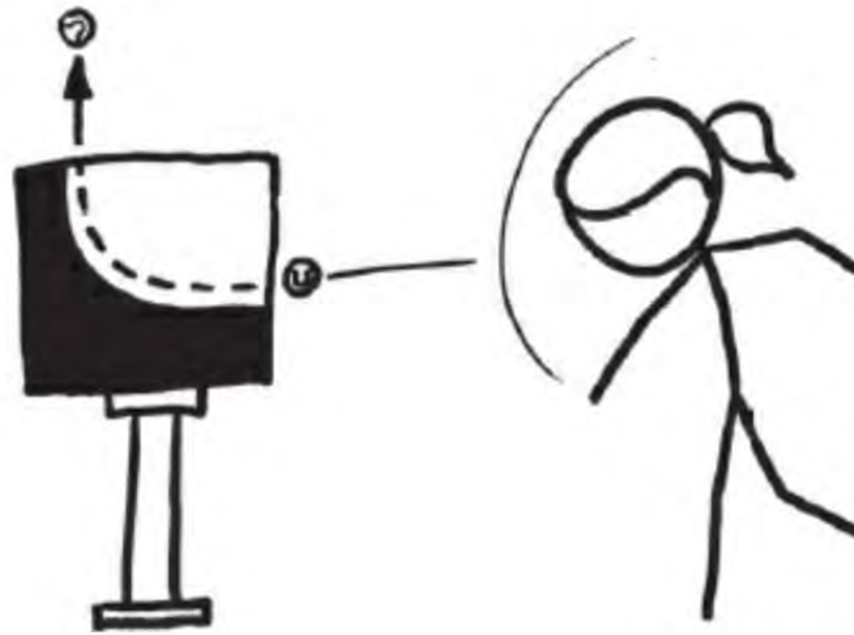
b. How high does the ball rise ($\equiv y_{max}$)?

$$y_{max} = \frac{V_o^2}{2g}$$

Aside:



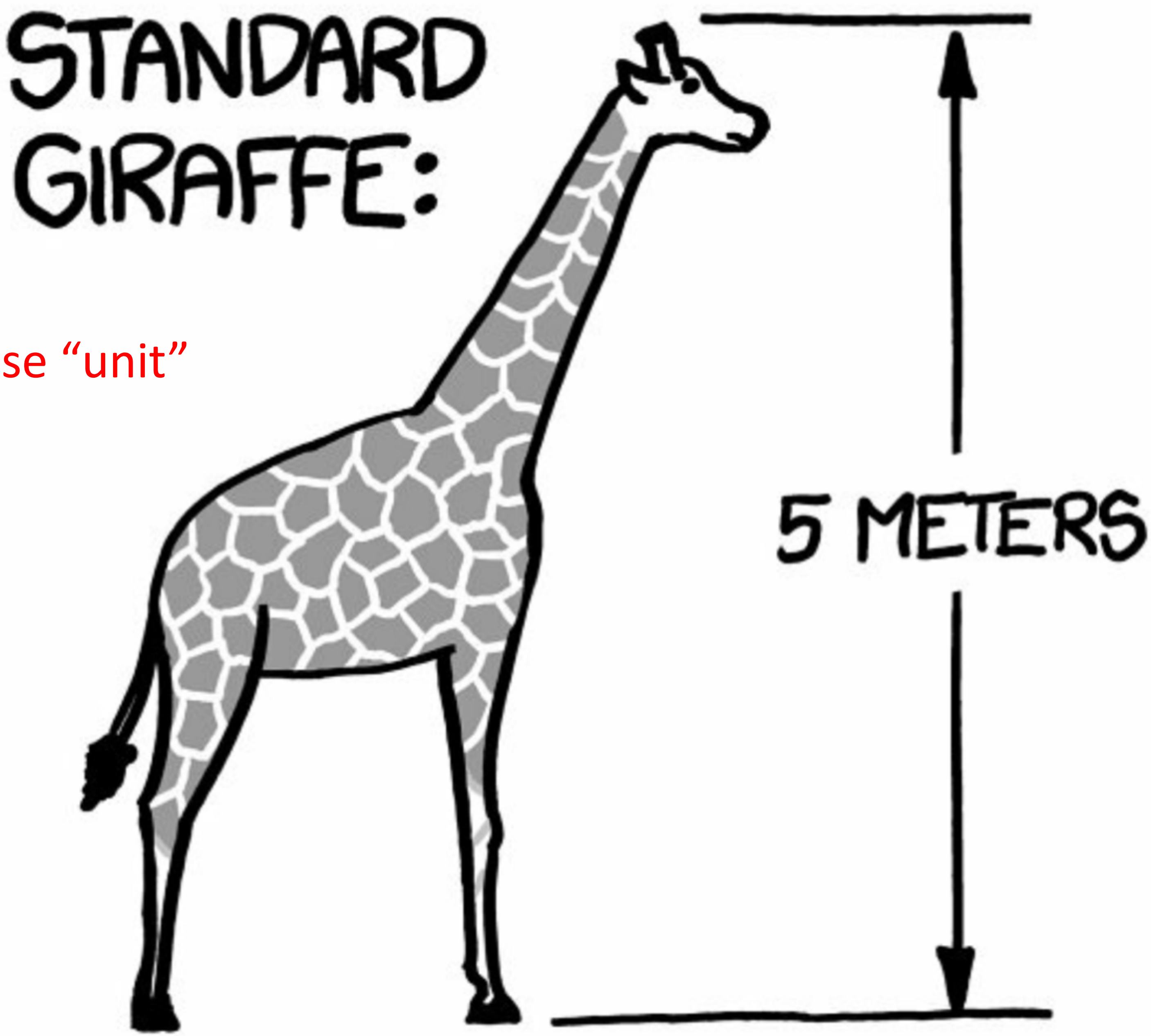




A mechanism for hitting yourself in the head with a baseball after a four-second delay

We could use a springboard, a greased chute, or even a dangling sling—anything that redirects the object upward without adding to or subtracting from its speed. Of course, we could also try this:

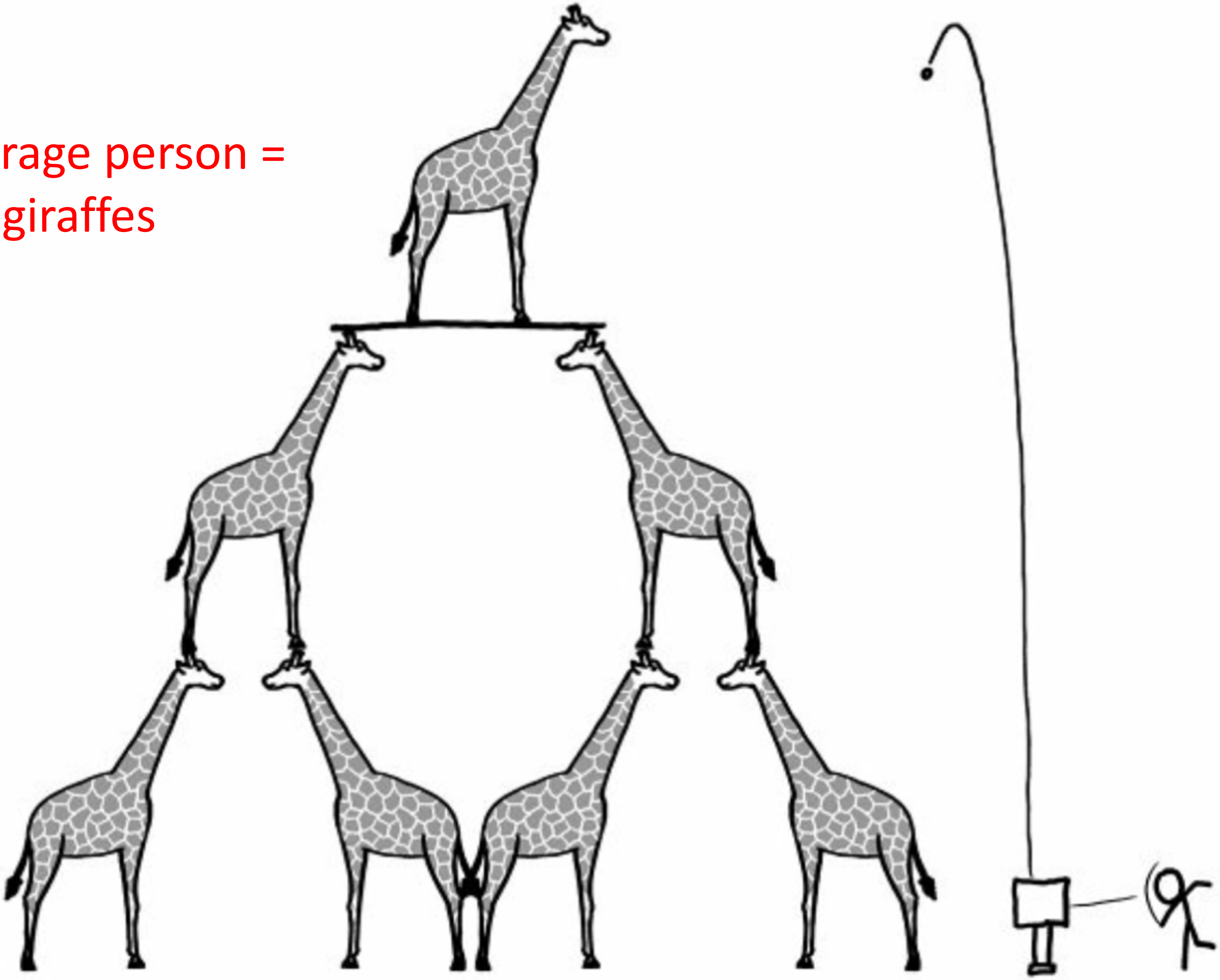
Munroe (2014)



Our base "unit"

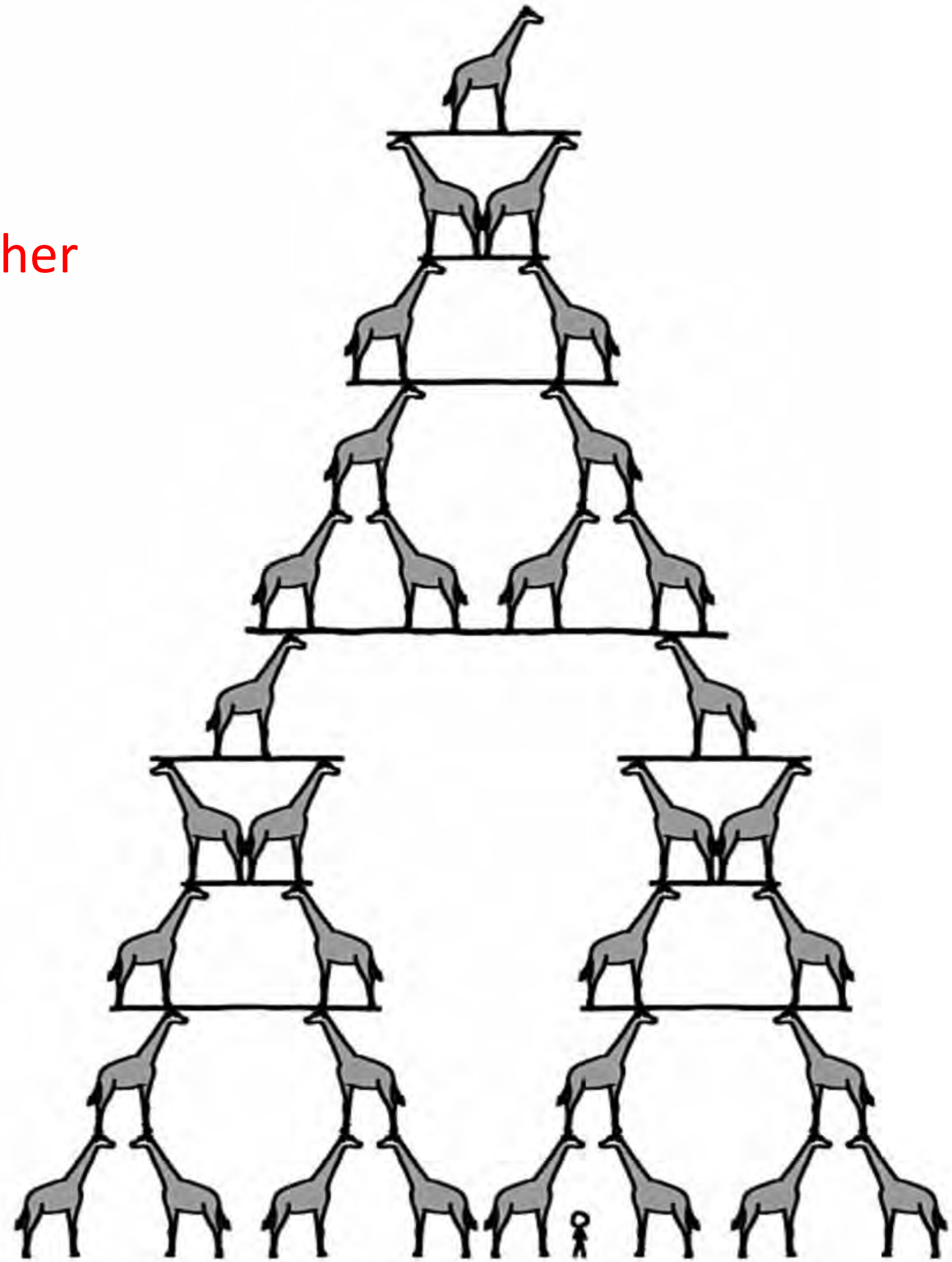
Munroe (2014)

Average person =
3-5 giraffes



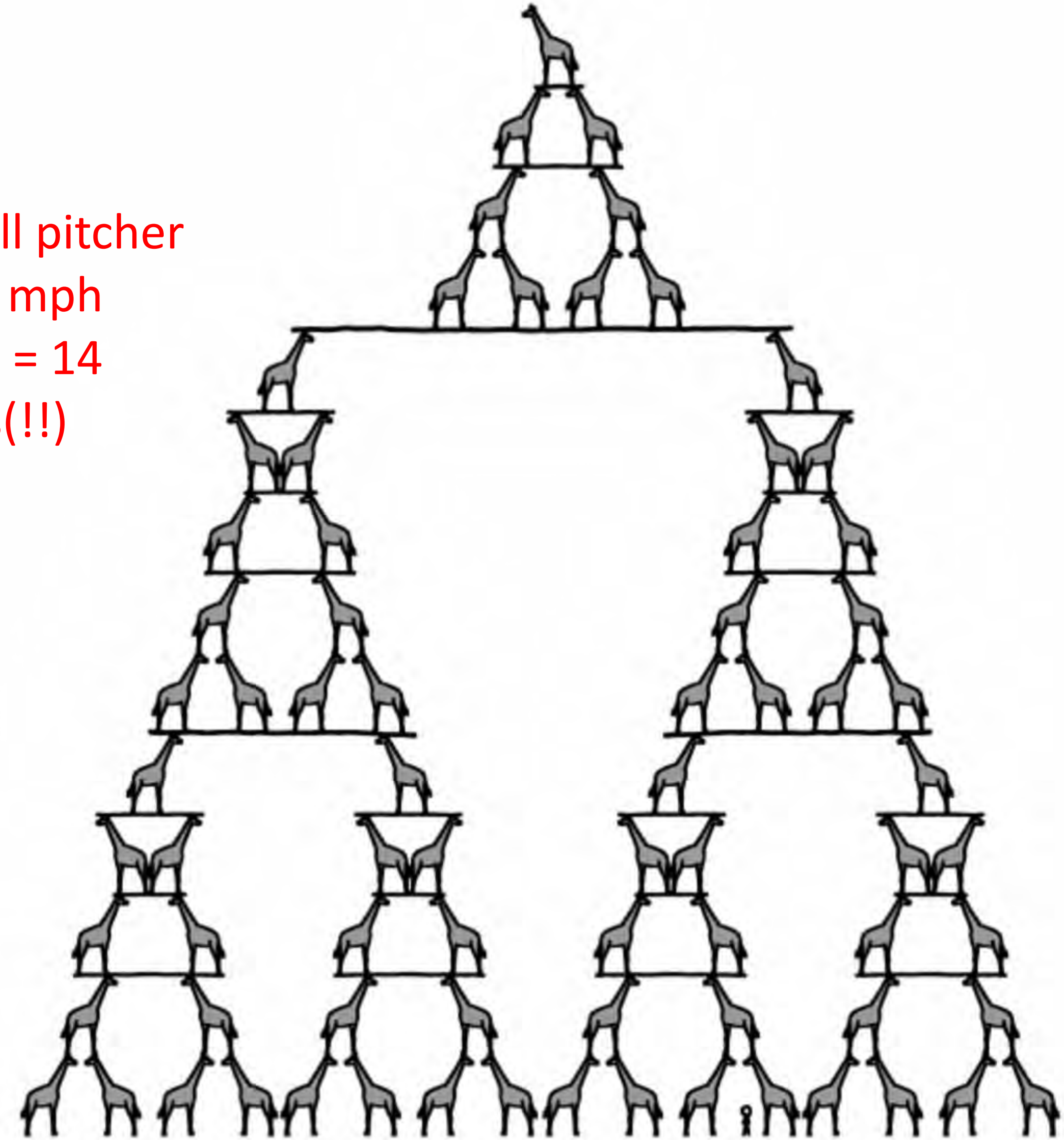
Munroe (2014)

Baseball pitcher w/ 80 mph fastball = 10 giraffes



Munroe (2014)

Baseball pitcher w/ 105 mph fastball = 14 giraffes(!!)



Munroe (2014)

Fact Check

Baseball pitcher w/ 105 mph fastball = 14 giraffes(!!)

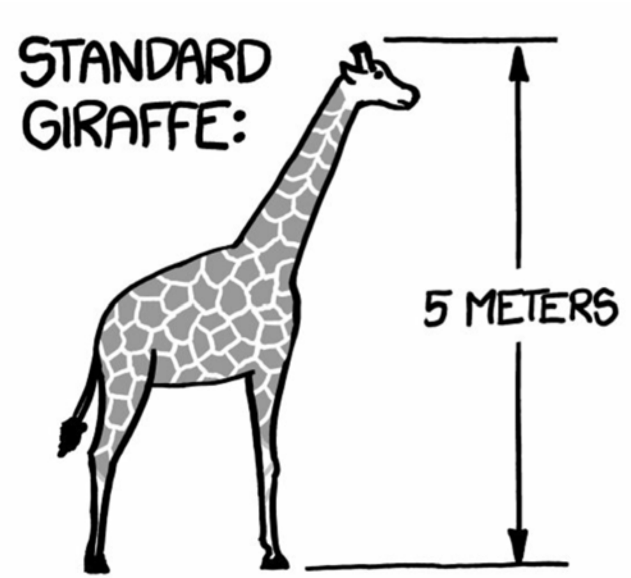
$$y_{max} = \frac{V_0^2}{2g}$$

Google

Speed

105 = 46.9392

Miles per hour | Metre per second



- $(46.9)^2/(2*9.8) = 112.2$ m
- 112.2 m ~ 22.4 giraffes

22.4 giraffes > 14 giraffes, so what gives?

→ Air resistance? “Aerodynamics”?

Munroe (2014)

47. ••Calc Assuming that Earth is a sphere of radius 6380 km and that the pressure is 1 atm at the surface, give a maximum estimate of the mass of the atmosphere.

11.47

SET UP

The pressure at the surface of the Earth is 1 atm, or 1.01×10^5 Pa. The weight of the atmosphere is equal to the atmospheric pressure multiplied by the surface area of the Earth. We can divide the weight of the atmosphere by g to get the mass of the atmosphere. The radius of the Earth is $R_E = 6.38 \times 10^6$ m.

SOLVE

$$P = \frac{F}{A} = \frac{Mg}{4\pi R_E^2}$$

$$M = \frac{4\pi P_{atm} R_E^2}{g} = \frac{4\pi(1.01 \times 10^5 \text{ Pa})(6.38 \times 10^6 \text{ m})^2}{9.8\frac{\text{m}}{\text{s}^2}} = \boxed{5.27 \times 10^{18} \text{ kg}}$$

44. ••**Calc** Determine the mass of a sphere of radius R that has a density that varies with distance from the center given by $\rho(r) = \rho_0(1 - r/R)$, where ρ_0 is a constant. For this problem, $0 < r < R$. *Hint*: $m = \int \rho \, dV$. To find the differential volume of a sphere, take the derivative of the volume of a sphere with respect to its radius, and solve for dV.

11.44

SET UP

The density of a sphere of radius R varies as a function of the distance from the center r: $\rho(r) = \rho_0\left(1 - \frac{r}{R}\right)$. We can find the mass of the sphere by integrating the density over the volume of the sphere: $m = \int \rho dV$. Since ρ is a function of r, we need to write the differential volume dV in terms of r. The easiest way of doing this is by differentiating the volume of a sphere $\left(V = \frac{4}{3}\pi r^3\right)$ with respect to r and then solving for dV. Plugging in this expression for dV will convert the integral from an integral over volume to an integral over the radius from $r = 0$ to $r = R$.

SOLVE

Finding dV:

$$V = \frac{4}{3}\pi r^3$$

$$\frac{dV}{dr} = 4\pi r^2$$

$$dV = 4\pi r^2 dr$$

Finding m:

$$m = \int \rho dV = \int_0^R \rho_0\left(1 - \frac{r}{R}\right)(4\pi r^2 dr) = 4\pi\rho_0\int_0^R\left(r^2 - \frac{r^3}{R}\right)dr = 4\pi\rho_0\left[\frac{r^3}{3} - \frac{r^4}{4R}\right]_0^R$$

$$= 4\pi\rho_0\left[\frac{R^3}{3} - \frac{R^4}{4R}\right] = 4\pi\rho_0\left[\frac{R^3}{12}\right] = \boxed{\frac{\pi}{3}\rho_0 R^3}$$

REFLECT

Our answer has dimensions of mass, as expected. A uniform sphere of density ρ_0 would have a mass of $\frac{4\pi}{3}\rho_0 R^3$. Because the density of this sphere decreases with the radius, we would expect the mass to be less than a uniform sphere.

63. •What force must the surface of a basketball withstand if it is inflated to a pressure of 8.5 psi? Assume the ball has a diameter of 23 cm.

11.63

SET UP

A basketball is inflated to a gauge pressure of 8.5 psi. The ball is 0.23 m in diameter. The force that the walls of the basketball must withstand is equal to this pressure difference multiplied by the surface area of the spherical ball. The conversion between psi and pascals is 14.7 psi = 1.01×10^5 Pa.

SOLVE

$$\Delta P = \frac{F}{A}$$

$$F = (\Delta P)A = \left(8.5 \text{ psi} \times \frac{1.01 \times 10^5 \text{ Pa}}{14.7 \text{ psi}}\right)(4\pi)\left(\frac{0.23 \text{ m}}{2}\right)^2 = \boxed{9.7 \times 10^3 \text{ N} = 9.7 \text{ kN}}$$

REFLECT

A pressure of 8.5 psi is about 0.6 atm.

95. •**Medical** Blood pressure is normally expressed as the ratio of the *systolic* pressure (when the heart just ejects blood) to the *diastolic* pressure (when the heart is relaxed). The measurement is made at the level of the heart (usually at the middle of the upper arm), and the pressures are given in millimeters of mercury, although the units are not usually written. Normal blood pressure is typically 120/80. How would you write normal blood pressure if the units of pressure used were (a) pascals, (b) atmospheres, or (c) pounds per square inch ($lb/in.^2$, psi)? (d) Is the blood pressure, as typically stated, the absolute pressure or the gauge pressure? Explain your answer. SSM

11.95

SET UP

A normal blood pressure is reported as 120/80, where the top number is the systolic pressure and the bottom number is the diastolic pressure. Both of these values are given in mmHg. We can rewrite these pressures in terms of other pressure units by applying the following conversion factors: 760 mmHg = 1.01×10^5 Pa = 1 atm = 14.7 psi. Blood pressure is an example of a gauge pressure, as 120 mmHg and 80 mmHg refer to the pressures *above* atmospheric pressure.

SOLVE

Part a)

Systolic:

$$120 \text{ mmHg} \times \frac{1.01 \times 10^5 \text{ Pa}}{760 \text{ mmHg}} = 1.59 \times 10^4 \text{ Pa}$$

Diastolic:

$$80 \text{ mmHg} \times \frac{1.01 \times 10^5 \text{ Pa}}{760 \text{ mmHg}} = 1.06 \times 10^4 \text{ Pa}$$

Blood pressure:

$$\boxed{\frac{1.59 \times 10^4 \text{ Pa}}{1.06 \times 10^4 \text{ Pa}}}$$

Part b)

Systolic:

$$120 \text{ mmHg} \times \frac{1 \text{ atm}}{760 \text{ mmHg}} = 0.158 \text{ atm}$$

Diastolic:

$$80 \text{ mmHg} \times \frac{1 \text{ atm}}{760 \text{ mmHg}} = 0.105 \text{ atm}$$

Blood pressure:

$$\boxed{\frac{0.158 \text{ atm}}{0.105 \text{ atm}}}$$

Part c)

Systolic:

$$120 \text{ mmHg} \times \frac{14.7 \text{ psi}}{760 \text{ mmHg}} = 2.32 \text{ psi}$$

Diastolic:

$$80 \text{ mmHg} \times \frac{14.7 \text{ psi}}{760 \text{ mmHg}} = 1.55 \text{ psi}$$

Blood pressure:

$$\boxed{\frac{2.32 \text{ psi}}{1.55 \text{ psi}}}$$

Part d) Blood pressure is reported as a gauge pressure. When you're cut, blood comes out of your arteries; the air doesn't rush in.

REFLECT

If the blood pressures reported were absolute pressures, these would be much smaller than atmospheric pressure. In that case, the pressure difference between the vessels and the outside air would compress all of our blood vessels shut, which luckily does not happen.