# Quiz 1 - Solutions

Physics for Pedestrians

23rd July, 2019

## From the Reading *Experiments Begun*

1. The first calculation of the value of acceleration due to gravity was performed by:
   (a) Galileo
   (b) Newton
   (c) **Huygens**
   (d) Torricelli
   (e) Pascal
2. Galileo verified that the distance travelled in free fall should be proportional to the square of the time by:
   (a) Dropping a 100 pound and 1 pound ball from the Tower of Pisa.
   (b) **Rolling spheres down inclined planes at different angles.**
   (c) Trick question: He didn't.

## Estimation Problems

1. $10^9$ seconds is $\approx$:
   (a) **100 years**
   (b) 10 years
   (c) 1 year
   (d) 1000 years
   (e) 10000 years

**Solution:** From the class, you should remember that a year is $\approx 10^7$ seconds. A 100 years would be $100 \times 10^7 s \approx 10^9 s$.

Suppose, however, that you didn't remember. In this case, just find the number of seconds in a day:

$$\begin{aligned} 1 \text{ day (in seconds)} &= 24 \times 60 \times 60 \text{seconds} \\ &\approx 20 \times 60 \times 60 \approx 70 \times 10^3 \text{seconds} \quad \approx 10^5 \text{seconds} \end{aligned} \tag{1}$$

This is much smaller than $10^9$, so let's find the number of seconds in a year:

$$\begin{aligned} 1 \text{ year (in seconds)} &= 365 \times 10^5 \text{seconds} \\ &\approx 3 \times 10^7 \text{seconds} \end{aligned} \tag{2}$$

From here, you should be able to see that $10^9$ seconds is closer to 100 years than to any of the other options.

2. You have a combination lock with three digits such that it has numbers from 000-999. Suppose an enterprising thief wants to open it by trying out all the combinations. How long would it take her/him?

   (a) **1 hour**

   (b) 12 hours

   (c) 1 day

   (d) 1 month

   (e) 1 year

**Solution:** You first need to know how many options you'd need to try out before you open the lock. The worst case scenario is 1000 options (all the numbers from 000 to 999).

Now, you imagine the thief trying one option after another. How long would it take? I estimate that turning the dial would take roughly 1 second. In this case, I could go through all the numbers in 1000 seconds = $10^3$s.

You should remember now that an hour has $60 \times 60$ seconds, which is $\approx 3000$s. Thus, this would take you about a third of an hour $\approx 20$ minutes. An hour is the closest estimate of the options provided.

**Why not 12 hours?** 12 hours would be $\approx 12 \times 3000 \approx 30,000$ seconds. This would mean 30 seconds per combination, which is too long.

3. Estimate the density (that is, the mass per unit volume) of a human being.

   (a) $10^{-2}$ kg/m$^3$

   (b) 1 kg/m$^3$

   (c) 10 kg/m$^3$

(d) **1000 kg/m$^3$**

(e) $10^5$ kg/m$^3$

**Solution:** There are many ways of solving this: one method would be to estimate your mass, and then estimate your volume, and divide the two, as shown in Figure (1):

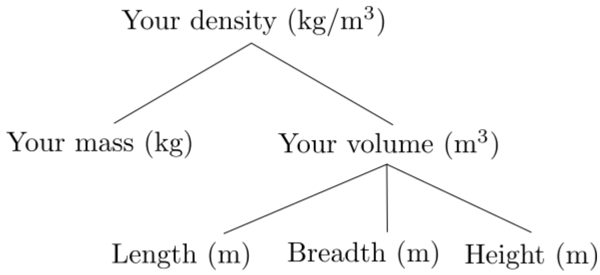


Figure 1: Tree-diagram to estimate density

Let's begin by the lowest level: estimating your volume. These are some numbers that I felt were reasonable.

$$\begin{aligned}
\text{Estimate of Height} &\approx 2 \text{ m} \\
\text{Estimate of Width} &\approx 30 \text{ cm} = 0.3 \text{ m} \\
\text{Estimate of Breadth} &\approx 15 \text{ cm} = 0.15 \text{ m}
\end{aligned}$$

From here,

$$\begin{aligned}
\text{Estimate of Mass} &\approx 100 \text{ kg} \\
\text{Estimate of Volume} &\approx (2 \text{ m}) \times (3 \times 10^{-1} \text{ m}) \times (15 \times 10^{-2} \text{ m}) = 90 \times 10^{-3} \text{ m}^3
\end{aligned}$$

Your density is thus:

$$\rho^{[1]} = \frac{\text{Estimate of Mass}}{\text{Estimate of Volume}} \approx \frac{100 \text{ kg}}{90 \times 10^{-3} \text{ m}^3} \approx 10^3 \frac{\text{kg}}{\text{m}^3}$$

**Another possible solution:** You know that you can float on water, but just barely. From this, you know that your density must be very close to the density of water, which you remember (perhaps) to be 1 g/cc (cc = cubic centimeter, or cm$^3$).

$$\frac{1 \text{ g}}{\text{cm}^3} = \frac{1 \text{ g}}{\text{cm}^3} \times \frac{1 \text{ kg}}{1000 \text{ g}} \times \left(\frac{100 \text{ cm}}{1 \text{ m}}\right)^3 = 10^3 \frac{\text{kg}}{\text{m}^3}$$

**A third solution:** Imagine a cube of 2 m $\times$ 1 m $\times \frac{1}{2}$ m.[2]. How many people could you squash in there? What would the total mass be, assuming each person to be 100 kg?

[1] This is the Greek letter 'rho', and is usually used as the symbol for density.
[2] Convince yourself that its volume is 1 m$^3$