Assignment 1 Solutions

1. Google: 100 billion stars in the Milky Way Galaxy

100 billion * 10% = 10 billion planets

10 billion * 1% = 100 million Earth-like planets

100 million * (1/1million) = 100 civs

2. Google: 1 light-year = $9.46 * 10^{12}$ km

Google: speed of Voyager-1 = 62140 km/h = 17 km/s

Time for Voyager-1: $2 * 9.46 * 10^{12} / 62140 = 3 * 10^{8}$ hours = $3.5 * 10^{4}$ years

Alien Spaceship: $2 * 9.46 * 10^{12} / 1000 / 365 / 24 / 3600 = 6 * 10^{2}$ km/s

3. Google: Distance between Earth and Moon is 384,000 km

$384{,}000 / (6*10^{2}) = 640$ s = 1 * 10 min

$384{,}000 / 17 = 2.3 * 10^{4}$ s = $4 * 10^{2}$ min

4. Google: Diameter of the Milky Way Galaxy is 100,000 light-years

100,000 light-years = $9.46*10^{17}$ km ~10^{18} km

10^{18} km needs to be scaled to 100 km, that would be 10^{16} times of shrink

Under that scale, Earth will be $6378/(10^{16})$ km = $6 * 10^{-10}$ m ~ 0.6 nanometers

The Earth will be as small as an atom. Completely invisible by eyes. Making such a model would be difficult because we would need handle individual atoms.

5. Google: Diameter of hair is 17~181 μm. Use any value in between for estimation.

Google: atomic radius of carbon atom is 70 pm, Van der Waals radius of carbon atom is 170 pm. Use any value in between for estimation

Google: weight of a grain of sand can be anywhere between 10 μg and 100 mg.

Google: weight of silicon atom is 28 u. u is the atomic mass unit.

1 u = $1.66 * 10^{-27}$ kg, therefore 28 u = $4.6 * 10^{-26}$ kg

# of carbon atoms in the width of hair is 10^{5} ~ 10^{7}

# of silicon atoms in the weight of a grain of sand is 10^{17} ~ 10^{22}

6. Over half a year, the distance is half of the circumference of the orbit circle, whereas the displacement is the diameter of the orbit circle.

Radius of the orbit of the Earth is $1.50 * 10^{8}$ km.

Half of circumference is Pi * radius = $3.14 * 1.50 * 10^{8}$ km = $4.71 * 10^{8}$ km

Average speed = $4.71 * 10^{8}$ km / 0.5 year = 29.8 km/s

Average velocity = $3.00 * 10^8$ km / year = 19.0 km/s

7. unit conversion: 65 km/h = 18 m/s

Acceleration = 18 / 5 = 3.6 m/s^2

Displacement = (1/2) * 3.6 * 5^2 = 45 m

8. (1/2) * g * t^2 = 112 m, where g = 9.8 m/s^2

t = 4.78 s.

In the time of (t-1s), the Spider-man fell: (1/2) * g * $(4.78 - 1)^2$ = 70.0 m

Therefore in the last one second, the Spider-man fell 112 - 70.0 = 42.0 m.