PHYX 106

Homework 1 — Units & 1–D Velocity

Due Monday, January 26

NOTE: The final answer cannot be more precise than the least precise input. Your final answers should therefore have no more significant figures than the number of significant figures in the least precise input value. Use scientific notation for quantities with magnitudes more than 10^4 or less than 10^{-2}.

Question 1. Furlongs and Fortnights. [6 pts.] When a physicist starts using strange, obscure units during a presentation... which happens more than you might think at first... his compatriots will often tease him by asking "How many furlongs per fortnight is that?" A furlong is a unit of length equal to 220 yards; a fortnight is a unit of time equal to 14 days. Convert the following quantities into a system of units based on furlongs and fortnights.

a) 50. mi/hr, the speed limit on the 101.

Answer: $\frac{50mi}{hr} \times \frac{24hr}{d} \times \frac{14d}{fortnight} \times \frac{1760yd}{mi} \times \frac{furlong}{220yd} = 1.34 \times 10^5 \frac{furlong}{fortnight}$

b) 4.5 cm/yr, the current northward speed of Australia.

Answer: $\frac{4.5cm}{yr} \times \frac{yr}{365d} \times \frac{14d}{fortnight} \times \frac{in}{2.54cm} \times \frac{yd}{36in} \times \frac{furlong}{220yd} = 8.58 \times 10^{-6} \frac{furlong}{fortnight}$

c) 60. Hz, the frequency of AC current in the US. (1 Hz = 1/sec).

Answer: $\frac{60}{s} \times \frac{3600s}{hr} \times \frac{24hr}{d} \times \frac{14d}{fortnight} = 7.26 \times 10^7 / fortnight$

d) 9.80665 m/s^2, the acceleration due to gravity at the Earth's surface.

Answer: $\frac{9.80665m}{s^2} \times \frac{100cm}{m} \times \frac{in}{2.54cm} \times \frac{yd}{36in} \times \frac{furlong}{220yd} \times \left(\frac{3600s}{hr}\right)^2 \times \left(\frac{24hr}{d}\right)^2 \times \left(\frac{14d}{fortnight}\right)^2 =$ $7.13256 \times 10^{10} \frac{furlong}{fortnight^2}$

e) 1 AU, defined to be the average distance between the Earth and Sun (1 AU = "Astronomical Unit" = 9.3×10^7 mi).

Answer: $9.3 \times 10^7 mi \times \frac{1760yd}{mi} \times \frac{furlong}{220yd} = 7.44 \times 10^8$ *furlong.*

f) 10 cc, the volume of medicine routinely given to patients in the TV show "ER" (1 cc = "cubic centimeter" = 1 cm^3).

Answer: $10cm^3 \times \left(\frac{in}{2.54cm}\right)^3 \times \left(\frac{yd}{36in}\right)^3 \times \left(\frac{furlong}{220yd}\right)^3 = 1.23 \times 10^{-12}$ *furlong*^{3}.

Question 2. CGS to MKS. [6 pts.] Convert the following fundamental physical constants from the CGS system into the MKS system. Note the use of, for instance, cm s^{-2} to indicate cm/s^2.

a) Newton's Gravitational Constant, $G = 6.673 \times 10^{-8}$ cm^3 g^{-1} s^{-2}.

Answer: $\frac{6.673\times10^{-8}cm^3}{g\cdot s^{-2}} \times \left(\frac{m}{100cm}\right)^3 \times \frac{1000g}{kg} = 6.673 \times 10^{-11}\frac{m^3}{kg\cdot s^2}$

b) The Speed of Light, $c = 3.00 \times 10^{10}$ cm s^{-1}.

Answer: $\frac{3.00\times10^{10}cm}{s} \times \frac{m}{100cm} = 3.00 \times 10^8\frac{m}{s}$.

c) Planck's Constant, $\hbar = 1.055 \times 10^{-27}$ g cm^2 s^{-1}

Answer: $\frac{1.055\times10^{-27}g\cdot cm^2}{s} \times \frac{kg}{1000g} \times \left(\frac{m}{100cm}\right)^2 = 1.055 \times 10^{-34}\frac{kg\cdot m^2}{s^2}$.

Question 3. Some Kinematic Concepts. [4 pts.]

a) For what physical phenomena can the Earth not be considered a particle?

Answer: When (for example) the rotation or size of the Earth makes a difference, such as (respectively) calculating the length of a day or when a falling object will hit the surface of the Earth.

b) When the velocity is constant, does the average velocity over any time interval ever differ from the instantaneous velocity at any instant?

Answer: No, when the velocity is constant, the instantaneous velocity is always the average velocity, since it never changes.

c) Does a car's speedometer actually measure speed... or is it velocity? Why or why not?

Answer: it measures speed, because it doesn't matter to the speedometer which direction you are going.

d) Can a body have zero displacement but nonzero speed?

Answer: Yes, anytime the body is in motion at the origin.

Question 4. A Conceptual Kinematic Problem. [4 pts.] Two trains, each having a speed of 50 km/hr are headed for each other on the same straight track. When the trains are exactly 77 km apart, a bird flies from one train to the other at 75 km/hr. On reaching the other train, it immediately turns around and flies towards the first train again, and so forth. What is the total distance (not displacement) the bird travels before the trains collide?

Answer: We need to know the bird's time in flight in order to calculate the total distance it travels. That time is the time until the trains collide:

$$\begin{aligned} x_{\text{trains}} &= v_{\text{trains}} t \\ t &= x_{\text{trains}}/v_{\text{trains}} \\ t &= 77 \text{ km}/(100 \text{ km/hr}) \\ t &= 0.77 \text{ hr.} \end{aligned}$$

So in that time the bird travels a distance

$$x_{\text{bird}} = v_{\text{bird}} t = 75 \frac{\text{km}}{\text{hr}} \times 0.77 \text{ hr} = 58 \text{ km.}$$

Total Points Possible: 20 + 5 Bonus.