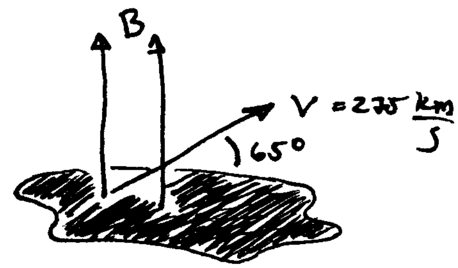
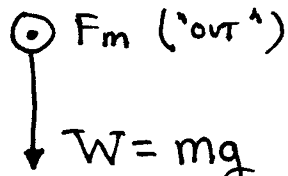
MANIC MONDAY #3 – CORONAL LOOPS

(A) The physical situation is shown to the right. The blob has 2 forces acting on it – GRAVITY and MAGNETIC FORCE

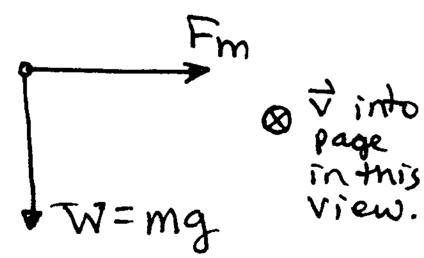


- Gravitational force: $F = mg$ pts DOWN
- Magnetic force: $F = qVB\sin\theta$ pts $\vec{V} \times \vec{B}$ direction (OUT OF PAGE above)

so// FREE BODY DIAGRAM



Free body diagrams are three dimensional things so if I look at the diagram from the viewpoint of the eyeball above it looks like this:



(B) The gyroradius of a charged particle is: $r = \frac{mV}{qB}$ ← V comp ⊥ to B

so//

$$B = \frac{mV}{qr} = \frac{(10^{-6}\,kg)(2.75\times10^{5}\,m/s)(\cos 65^{\circ})}{(10^{-7}\,C)(5.8\times10^{6}\,m)}$$

↖ $\cos 65^{\circ} \cdot V = V_{\perp}$

$\boxed{B = 0.20\,T}$ STRENGTH OF B FIELD

→

(C) The components are easy to compute because the two forces in our free body diagram are mutually orthogonal (by the problem setup). In this case the component magnitude of the acceleration is just: $a = F/m$

so//

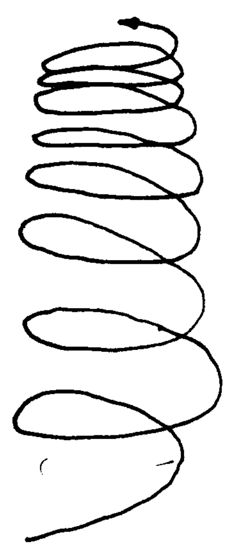
$$a_{VERTICAL} = \frac{F_{vertical}}{m} = \frac{m\, g_{SUN}}{m} = g_{SUN} = \frac{G M_\odot}{R_\odot^2}$$

$$= \frac{6.67\times10^{-11}\,\frac{Nm^2}{kg^2}\cdot 1.989\times10^{30}\,kg}{(6.9598\times10^{8}\,m)^2} = \boxed{274\ m/s^2}$$

$$a_{HORIZ} = \frac{F_{HORIZ}}{m} = \frac{F_{magnetic}}{m} = \frac{q\overset{V \perp \text{ to } B}{V}B}{m} = \frac{qV\cos\theta\, B}{m}$$

$$= \frac{(10^{-7}\,C)(2.75\times10^{5}\,m/s)\cos 65^\circ\,(0.20T)}{(10^{-6}\,kg)} = \boxed{2325\ m/s^2}$$

(D) The horizontal force due to the magnetic field makes it want to travel in a circle. Since it has upward velocity, it will trace out a helix. Since it is slowing down as it travels up, the coils of the helix will become more compressed.



(E) The best kinematic eqn to use to estimate height in this case is: $v^2 = v_0^2 + 2a\Delta y \Rightarrow v^2 = v_0^2 + 2g_{SUN}\Delta y$

or// $\Delta y = \text{height} = \dfrac{v^2 - v_0^2}{2g_{SUN}}$

Δy	v_0	v	a	t
?	$v_0 \sin\theta = 2.49\times10^5 \frac{m}{s}$	$0\frac{m}{s}$	$-274\frac{m}{s^2}$	?

$$= \frac{(0\,m/s)^2 - (2.49\times10^5\,m/s)^2}{2\cdot(-274\,m/s^2)}$$

$$= \boxed{1.13\times10^8\,m} \simeq 89 \text{ EARTH DIAMETERS !}$$

(F) It is now easy to find the time, again using kinematics:

$$v = v_0 + at \Rightarrow v = v_0 + g_{SUN}t$$

or// $t = \dfrac{v - v_0}{g_{SUN}} = (-)\dfrac{2.49\times10^5\,m/s}{274\,m/s^2} = \boxed{908.7s \simeq 15.1\,min}$

(G) I can relate current $I = \frac{Q}{\Delta t}$ to speed $v = \frac{\ell}{\Delta t}$ by getting rid of Δt:

$v = \frac{\ell}{\Delta t} \rightarrow \Delta t = \ell/v$ so// $I = \frac{Q}{\Delta t} = \frac{Q}{\ell/v} = v\cdot Q/\ell$

The AVERAGE current depends on AVERAGE speed: $v_{av} = \frac{1}{2}(v_0 + \cancel{v_f}) = \frac{1}{2}v_0$

0 at top of loop

so// $I_{av} = \dfrac{v_0 Q}{2\ell} = \dfrac{(2.49\times10^5\,m/s)(10^{-7}c)}{2(1.13\times10^8\,m)} = \boxed{1.1\times10^{-10}\,Amp}$ TINY!

(H) The total number of blobs in loop is:

$$N_b = \frac{m_{LOOP}}{m_{BLOB}} = \frac{10^{13}\,kg}{10^{-6}\,kg} = 10^{19}\text{ blobs}$$

So the total charge in the loop is

$$Q_{TOT} = N_b \cdot q_{blob} = 10^{19} \cdot (10^{-9}C) = \boxed{10^{10}C}$$

TEN BILLION coulombs is a LOT of charge!