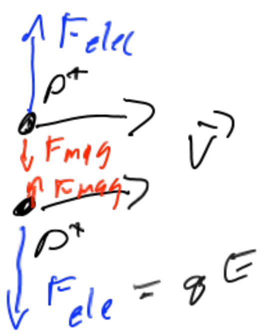
March 25

Ponderable: Jack and Jill (and Einstein)



Jack: in lab frame

$p^+ \rightarrow \vec{v} = v$

Jill: moving with the p^+

$p^+ \rightarrow \vec{v} = 0$

$$F_e = \frac{1}{4\pi\epsilon_0}\frac{q^2}{r^2}$$

$$F_{mag} = q(v_2 \times B_1) = qv\frac{\mu_0}{4\pi}\frac{q(v_1 \times \hat{r})}{r^2} = \frac{\mu_0}{4\pi}\frac{q^2 v^2}{r^2}$$

$$\frac{F_{mag}}{F_{elec}} = \frac{\frac{\mu_0}{\cancel{4\pi}}\frac{\cancel{q^2} v^2}{\cancel{r^2}}}{\frac{1}{\cancel{4\pi}}\frac{1}{\epsilon_0}\frac{\cancel{q^2}}{\cancel{r^2}}} = \mu_0\epsilon_0 v^2 = \frac{v^2}{(3\times 10^8\,m/s)^2} = \frac{v^2}{c^2}$$

Jack: $F_T = F_{elec} + F_{mag} = \frac{1}{4\pi\epsilon_0} q^2 \left(1 - \frac{v^2}{c^2}\right)$

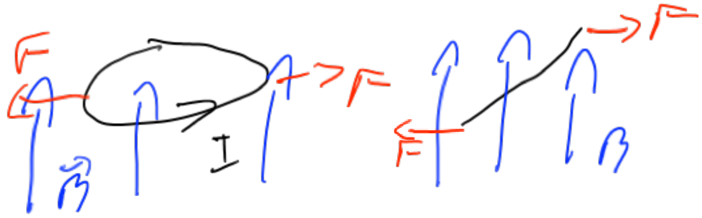
Jill: $p^+ \rightarrow v = 0 \rightarrow F_T = F_{ele}$

two different forces $\rightarrow$ two different accelerations

There is no universal time!

c is what is universal

Ponderable: Torque on a loop

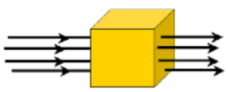


stable equilibrium

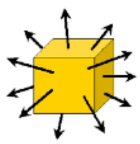
unstable equilibrium

Chapter 21

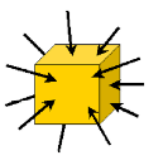
Ponderable: What's in the box?



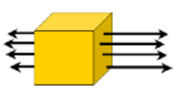
nothing



$+q$



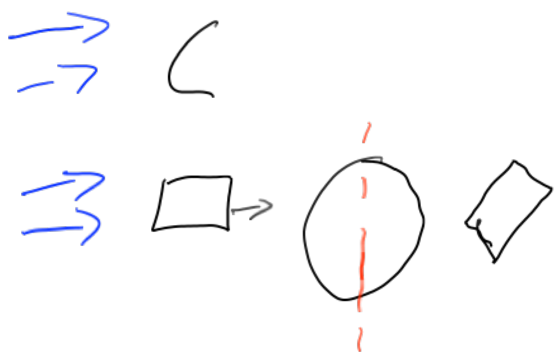
$-q$



sheet of charge

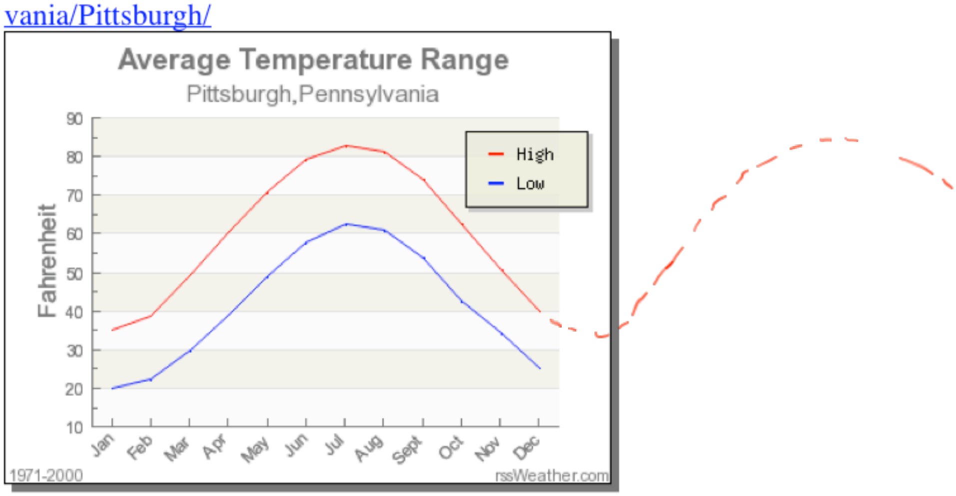
Ponderable: Flux Ranking

Whose On Top?

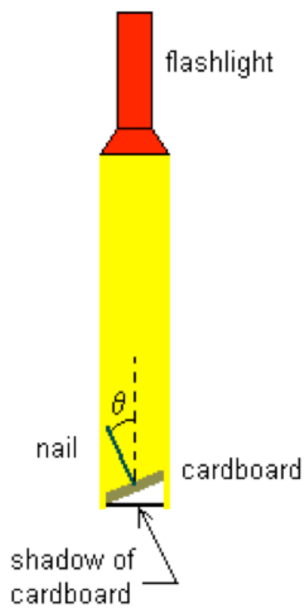


Tangible: Flux-uating Weather

http://www.rssweather.com/climate/Pennsylvania/Pittsburgh/



Tangible: Made in the Shade



Discussion: Flux

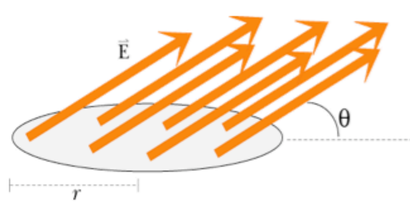
$$\Phi_{El} = \sum_{\text{surfaces}} \vec{E} \bullet A\hat{n}$$

$$|\vec{E}||\hat{n}| \cos\theta$$

$$\Phi = A|\vec{E}||\hat{n}| \cos\theta$$

Q21.2a

E = 600 V/m, r=3 cm, θ = 25 degrees



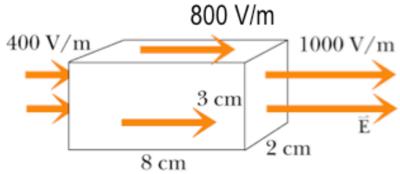
What is the electric flux on this disk-shaped surface?

A. 600 V · m
B. 253 V · m
C. 1.70 V · m
D. 1.54 V · m
E. 0.717 V · m

$$\Phi = A\,|E|\,|\hat{n}|\cos\theta$$

$$= \pi(.03)^2\,(600\,\tfrac{V}{m})\sin 25 = .717\,V\cdot m$$

Q21.2b



What is the net electric flux on the box?

A. 0 V·m
B. 0.36 V·m
C. 0.84 V·m
D. 8.04 V·m
E. 8.52 V·m

$\vec{E} \cdot \hat{n} = |\vec{E}||\hat{n}|\cos\theta$

$\Phi = \sum \vec{E} \cdot A\hat{n}$

$= -400(.03)(.02) + 1000(0.03)(.02) = 0.36\ V{\cdot}m$

Demo: VPython Gauss' Law Demo

Ponderable: Gauss' Law

$Q = 5 \times 10^{-6}\ C$

$\Phi = \sum \vec{E} \cdot A\hat{n}$

a) $r = 1m$

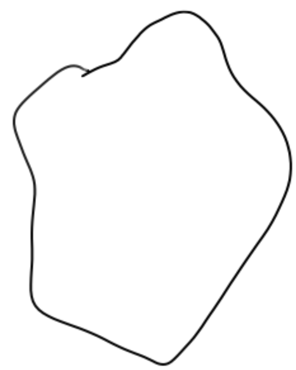
b) $r = 2m$

c) $r = 3m$

$\Phi = \sum \vec{E} \cdot \hat{n} A = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}(4\pi r^2) = \frac{Q}{\epsilon_0} = 5.6 \times 10^{-6}\ V \cdot m$

$$E = \frac{1}{4\pi\epsilon_0}\frac{2Q}{Lr}$$

$$A = 2\pi r L$$



$$\Phi = \frac{1}{4\pi\epsilon_0}\frac{2Q}{Lr}(2\pi r L) = \frac{Q}{\epsilon_0}$$

sheet

$$E = \left(\frac{Q/A}{2\epsilon_0}\right)$$

$$\Phi = \sum EA = E_{left}A_{left} + E_{right}A_{right}$$

$$= \frac{2(Q/A)A}{2\epsilon_0} = \frac{Q}{\epsilon_0}$$

$$\Phi = \sum E\cdot\hat{n}A = \frac{\sum Q_{inside}}{\epsilon_0}$$