Announcements

1) Don't do #16 on homework

2) Neutrino experiment

- GPS used to synchronize clocks that timed neutrino departure and arrival

Detect neutrino via

Interaction [illegible]

pions (combination of an up quark and "anti" down quark) (opposite charge)

which decay rapidly (2.6×10^{-8} s) into neutrinos

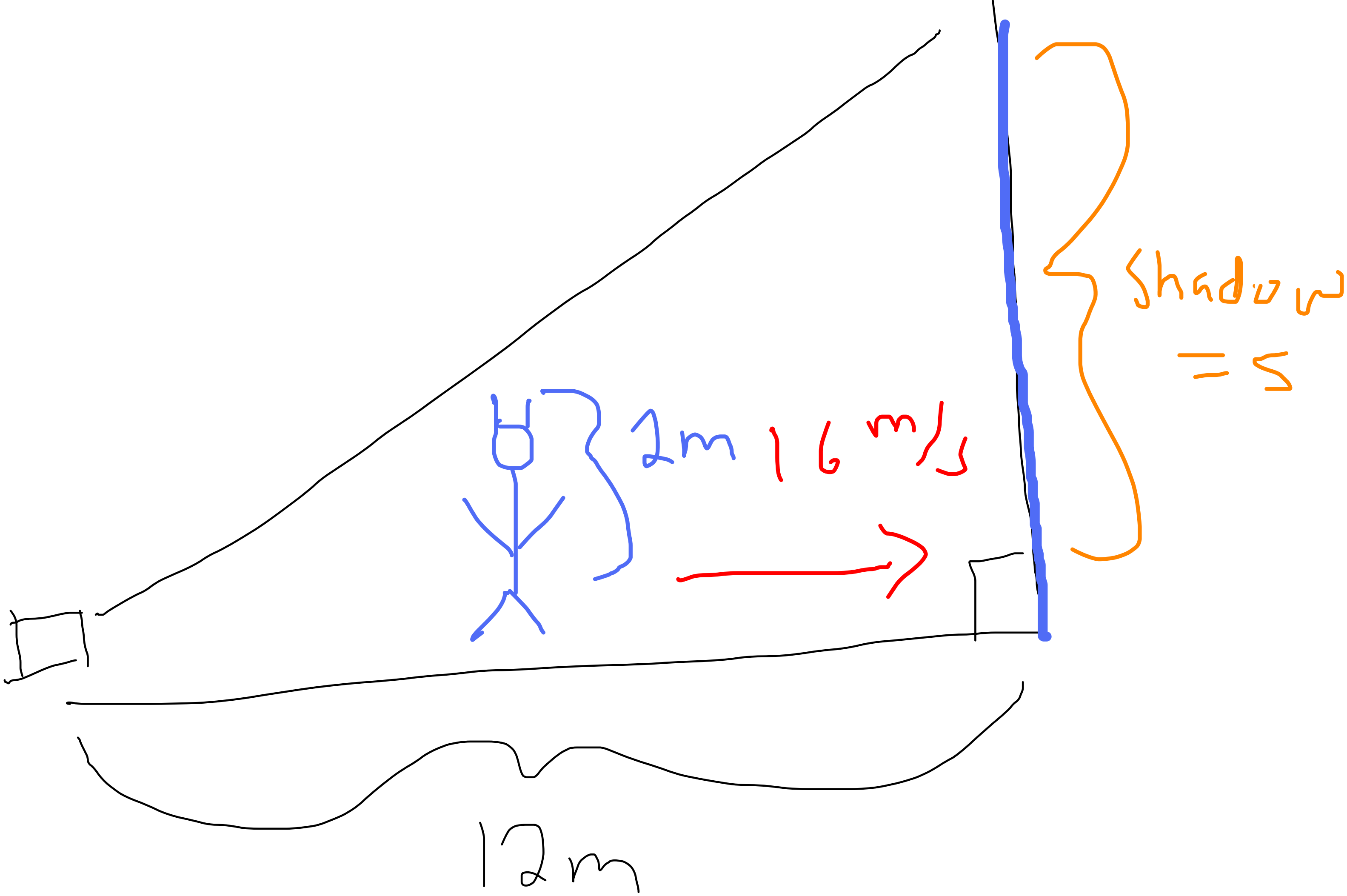
Proton = 2 ups, one down

3) Lutzer

pp. 251 – 259

(related rates)

shines on a wall 12 m away.
If Batman is 2 m. tall
walks from the spotlight
toward the building at a
speed of 1.6 m/s how fast
is the length of his shadow
on the building decreasing
when he is 4 m away
from the building?



Want $\frac{ds}{dt}$

We have the relationship

$$\frac{12}{5} = \frac{x}{2}$$

Differentiate with respect to t.

$$\frac{d}{dt}(xs) = \frac{d}{dt}(24) = 0$$

$$\parallel$$

$$x\frac{ds}{dt} + s\frac{dx}{dt} = 0$$

product rule

$$\frac{ds}{dt} = -\frac{s}{x}\frac{dx}{dt}$$

We know $\frac{dx}{dt} = 1.6 \ m/s$,

want when $x = 8 = 12 - 4$

since $x =$ distance Batman walks, not how close he is to the building.

solve for s when $x=8$.

$s=3$, so

$$\frac{ds}{dt} = -\frac{3}{8} \cdot 1.6 \text{ m/s}$$

$$= \boxed{-\frac{3}{5} \text{ m/s}}$$

Calculus in Applications

(section 2.7)

Math figures prominently in economics, physics, engineering, biology, and medicine.

Example 2. Lennard-Jones model for potential energy between atoms of argon gas

$$u(x) = k\left(1759.37x^{-12} - x^{-6}\right)$$

x = distance between centers of atoms (angstroms)

k = 70.3748752

(implicit derivative)

c) Find distance at which the atoms experience no force due to potential

a) $u(x) = k\left(1759.37\,x^{-12} - x^{-6}\right)$

$$u'(x) = k\left(1759.37(-12)\,x^{-13} - (-6)\,x^{-7}\right)$$

$$= k\left(21112.44\,x^{-13} + 6\,x^{-7}\right)$$

$$\frac{dU}{dm} = k\left(1759.37(-12)x^{-13}\frac{dx}{dm} + 6x\frac{dx}{dm}\right)$$

c) Force due to potential

is $\frac{dU}{dm}$. Solve

for $\frac{dU}{dm} = 0$.

Note! $\frac{dx}{dm} \neq 0$.

$$0 = k\left(1759.37(-12)x^{-13}\frac{dx}{dm} + 6x^{-7}\frac{dx}{dm}\right)$$

divide by k and $\frac{dx}{dm}$ on both sides to get

$$0 = \left(-21112.44x^{-13} + 6x^{-7}\right)$$

$$= \frac{-21112.44}{x^{13}} + \frac{6}{x^{7}}$$

$$= \frac{-21112.44 + 6x^{6}}{x^{13}}$$

$$x^6 = \frac{2112.44}{6}$$

$$x = \sqrt[6]{\frac{2112.44}{6}}$$

$$= \sqrt[6]{351.8.74} \text{ Ang}$$

$$\approx 355.91 \text{ Ang}$$

$$\sqrt{1-\left(\frac{v}{c}\right)^2}$$

m_0 = rest mass of an object (kg)

v = velocity of object (m/s)

c = speed of light

m = mass of object.

Note: $v = c$ gives zero on the denominator.

Equation

$$m = \frac{m_0}{\sqrt{1 - \left(\frac{v}{c}\right)^2}}$$

is called the Lorentz equation (I think),

a) Find $m'(v)$,

$$m = \frac{m_0}{\sqrt{1-\left(\frac{v}{c}\right)^2}}$$

$$= m_0\left(1-\left(\frac{v}{c}\right)^2\right)^{-1/2}$$

$$\frac{v^2}{c^2} = $$

$$\frac{dm}{dv} = m_0\left(-\tfrac{1}{2}\right)\left(1-\left(\frac{v}{c}\right)^2\right)^{-3/2}\frac{d}{dv}\left(1-\left(\frac{v}{c}\right)^2\right)$$

$$= +\frac{m_0}{\cancel{2}}\left(1-\left(\frac{v}{c}\right)^2\right)^{-3/2}\left(+\frac{\cancel{2}v}{c^2}\right)$$

$$= m_0\left(1-\left(\frac{v}{c}\right)^2\right)^{-3/2}\left(\frac{v}{c^2}\right)$$

b) find relationship between mass and derivative (For you in your free time)

$$v = \frac{P}{4\eta l}(R^2 - r^2)$$

P = constant

l = constant (length of vessel - small)

R = constant (radius of blood vessel)

r = distance from the central axis of blood vessel

η = viscosity (constant)