September 15

Clickers:

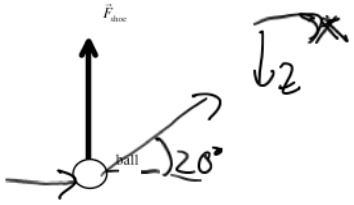
1. **Get a clicker.**
2. **Write down your number. This will be yours for the remainder of the semester.**

Ponderable: You'll get a kick out of this

You kick a soccer ball as it rolls by. Your kick is perpendicular to its initial path. The ball ends up being deflected by 20 degrees, but stays on the ground. How hard did you kick it?

Need to find mass of soccer ball, estimate speed, estimate collision time.

System: Ball Surroundings: earth, shoe



$$\vec{p}_f = \vec{p}_i + \vec{F}_{net}\Delta t$$

$$\langle mv_{xf}, 0, mv_{zf}\rangle = \langle mv_{xi}, 0, 0\rangle + \langle 0, F_{grass} - F_{Earth}, F_{shoe}\rangle \Delta t$$

$$v_{xf} = v_{xi} \quad \text{and} \quad \frac{mv_{zf}}{\Delta t} = F_{shoe}$$

$v_i = 3.5\ m/s$

$\Delta t = 0.002\ s$

$$\text{Direction of } \vec{v} = \hat{v} = \langle \cos 20^\circ, 0, \cos 110^\circ\rangle = \langle 0.9397, 0, -0.342\rangle$$

$$\vec{v} = \langle 3.5, 0, v_{zf}\rangle \tfrac{\text{m}}{\text{s}} = |\vec{v}|\hat{v} = |\vec{v}|\langle 0.9397, 0, -0.342\rangle \quad \text{so } |\vec{v}| = 3.725\ \tfrac{\text{m}}{\text{s}}$$

$$v_{zf} = \left(3.725\ \tfrac{\text{m}}{\text{s}}\right) \times (-0.342) = -1.274\ \tfrac{\text{m}}{\text{s}}$$

$$F_{shoe} = \frac{mv_{zf}}{\Delta t} = \frac{0.40\text{ kg} \times \left(-1.274\ \tfrac{\text{m}}{\text{s}}\right)}{0.002\text{ s}} = -250\text{ N} \qquad \vec{F}_{shoe} = \langle 0, 0, -250\rangle\text{ N}$$

Clickers:

1. **Get a clicker.**
2. **Write down your number. This will be yours for the remainder of the semester.**
3. **Turn on clicker.**
4. **Follow directions when they come up on screen.**

Q1

The windshield of a bus traveling at high speed hits a hovering insect and smashes it. Which of the following is true?

A (A) The magnitude of the change of velocity of the insect is larger than that of the bus.

B (B) The magnitude of the change of velocity of the bus is larger than that of the insect.

C (C) The magnitudes of these two velocity changes are equal.

Q2

The windshield of a bus traveling at high speed hits a hovering insect and smashes it. Which of the following is true?

A 1) The magnitude of the change of momentum of the insect is larger than that of the bus.

B 2) The magnitude of the change of momentum of the bus is larger than that of the insect.

C 3) The magnitudes of these two momentum changes are equal.

Q3

The windshield of a bus traveling at high speed hits a hovering insect and smashes it. Which of the following is true?

A 1) The windshield exerts a larger force on the insect than the insect exerts on the windshield.

B 2) The insect exerts a larger force on the windshield than the windshield exerts on the insect.

C 3) The magnitudes of these two forces are equal.

$M_{bus}\Delta V_{bus}$

$= M_{bug}\Delta V_{bug}$

Collision time is same $\Delta t_b = \Delta t_b$

$F_{bus}\Delta t = \Delta p_{bus} = \Delta p_{bug} = F_{bug}\Delta t$

$\Rightarrow F_{bus} = F_{bug}$

Reciprocity

true for gravity

Electrostatic force

Not true for magnetism

Discussion: Four fundamental forces

Gravity: $\vec{F}_{\text{grav on 2 by 1}} = -G\frac{m_1 m_2}{|\vec{r}|^2}\hat{r}$ $\quad \vec{r} = \vec{r}_{21} = \vec{r}_2 - \vec{r}_1$

$\vec{r} = \vec{r}_2 - \vec{r}_1$ $\quad \hat{r} = \frac{\vec{r}}{|\vec{r}|}$

$G = 6.7\times10^{-11}\ \frac{N m^2}{kg^2}$

Electromagnetism:

$\vec{F}_{\text{elec on 2 by 1}} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{|\vec{r}|^2}\hat{r}$

$\frac{1}{4\pi\varepsilon_0} = 9\times10^9\ \frac{N m^2}{C^2}$

Strong force: hold proton + neutrons together

Weak force: Cause certain types of radioactive decay

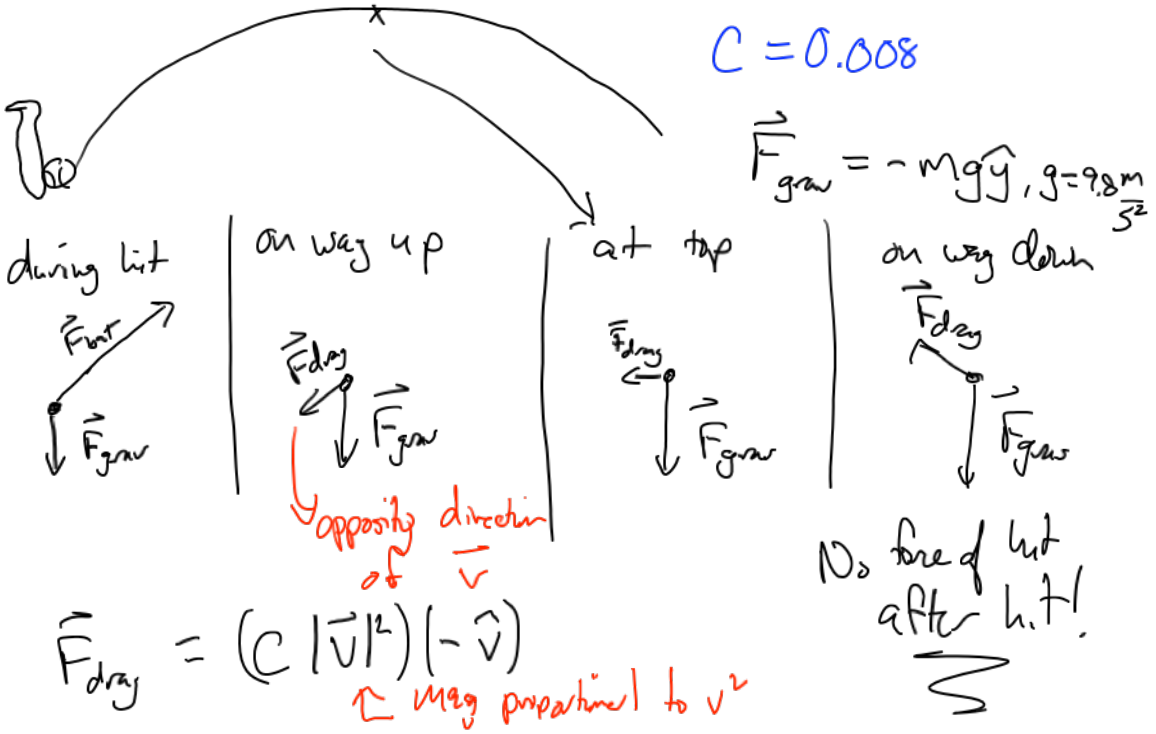
$n \rightarrow p + e^- + \bar{\nu}_e$

Ponderable: This is a drag

System: ball

$C = 0.008$

$\vec{F}_{grav} = -mg\hat{y}$, $g = 9.8 \frac{m}{s^2}$



$$\vec{F}_{drag} = (C|\vec{v}|^2)(-\hat{v})$$

↑ mag proportional to v^2

VPython Earth and Sun