Physics 113 - September 20, 2012

- Exam I - Oct 4 (2 weeks)
- No lecture meetings next week
  - Slides/Audio will appear on class website
- Expect some delay in answering e-mails over this weekend and next. Apologies in advance.
Last Time

\[ \mathbf{\ddot{s}(t)} = \mathbf{a}(t) \]

\[ \mathbf{\ddot{v}(t)} = \mathbf{g} \]

\[ \mathbf{\ddot{s}(t)} = \mathbf{s}_x \mathbf{\hat{i}} + \mathbf{s}_y \mathbf{\hat{j}} + \mathbf{s}_z \mathbf{\hat{k}} \]

\[ \mathbf{\ddot{v}(t)} = \mathbf{v}_x \mathbf{\hat{i}} + \mathbf{v}_y \mathbf{\hat{j}} + \mathbf{v}_z \mathbf{\hat{k}} \]

\[ \mathbf{\ddot{a}(t)} = a_x \mathbf{\hat{i}} + a_y \mathbf{\hat{j}} + a_z \mathbf{\hat{k}} \]

Projectile Motion
**Newton's Law of Gravitation**

\[ F = \frac{G m_1 m_2}{r^2} \]

At Surface of Earth

\[ F = \frac{G M_{\text{Earth}} m}{R_{\text{Earth}}^2} \]

\[ g = 9.8 \text{ m/s}^2 \]

Along the line joining masses

Attractive force

\[ F = ma \]

\[ F = mg \]
Newton's Laws

I: Law of Inertia
A body persists in its state of motion unless acted on by an external net force.

II: Force Law
The acceleration of an object is proportional to the net force applied to it and inversely proportional to the mass of the object.

\[ F = ma \]

III: Law of Action and Reaction
For every action there is an equal and opposite reaction.
Vector equation

\[ \sum \vec{F} = m \vec{a} \]

Equivalent to

3 one-dim equations

\[ \sum F_x = ma_x \]
\[ \sum F_y = ma_y \]
\[ \sum F_z = ma_z \]
The Path to Enlightenment

1. Understand problem, draw neat diagram of overall problem
2. Draw free body diagram of each relevant object - label with forces
3. Choose convenient coordinate system for each object
4. Apply Newton’s second law \( \sum F = ma \) in appropriate orthogonal coordinates (coordinates chosen for each body must be related to those chosen for other bodies)
5. Keeping symbols in place (not yet!), solve resulting set of equations simultaneously
6. Check answer with limiting cases and dimensional analysis!

Next FBD’s will help

Sketch in response to question about coords for each diagram having to be the same

Go slow + systematically
Example

Man has mass 70 kg
Heliocopter
Accelerates upward at \(4 \text{ m/s}^2\)

What tension must rope withstand?
\[ \sum F_y = T - m_\text{H} g = m_\text{m} a \]

\[ F = ma \]

\[ m_\text{H} g \]

\[ m_\text{m} g \]

\[ \text{Net Force} \]

\[ 70 \quad 9.8 \quad 70 \]
\[ T - m_m g = m_m a \]

\[ T = m_m (a + g) = 966 \text{ Newtons} \]
Example

Atwood's Machine

\[ M_1 = 6 \text{ kg} \]
\[ M_2 = 10 \text{ kg} \]

Syst at rest is released.
What is the acceleration of the system?
\[ \sum F_x = M_1 a = T - M_1 g \quad \sum F_y = M_2 a = -T + M_2 g \]

Negns, N unknowns \( \rightarrow \) can solve
\( (2) \)  \( \rightarrow \)  \( (2) \)
\[ a = \left( \frac{M_2 - M_1}{M_1 + M_2} \right) g \]

\[ T = M_2 \left( g - \frac{m_2 g - m_1 g}{M_1 + M_2} \right) \]

\[ T = \frac{2g M_1 M_2}{(M_1 + M_2)} \]

Check limiting cases: \( M, \) bis \( M_2 \) bis

Check units