Physics 4A-Review

I. Kinematics

(1) $x = \frac{1}{2}aT^2 + v_0T + x_0$
(2) $v_f = aT + v_0$

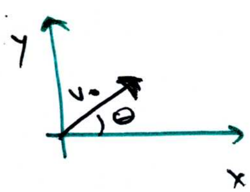
$\Rightarrow$ (3) $v_f^2 = v_0^2 + 2a\Delta x$

extend to arbitrary dimensions

what assumptions did we make to derive these? :

+ $a \equiv$ constant
+ objects are "point-particles" (or, equivalently, the vectors above describe COM coordinates)

ex



1) Find θ to max. x
2) Find θ to max. y
3) what is $\frac{dy}{dx}$ in terms of trig functions?

II. Forces

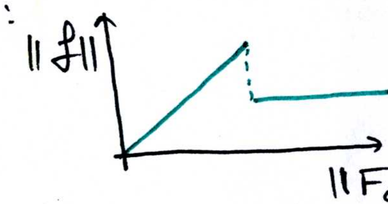
Newton: (1) $F_{net} = 0 \Rightarrow$ stays @ rest
(2) $F_{net} = ma$
(3) reaction = -action

describes isolated system motion
describes non-isolated system motion
describes non-isolated system interactions

To use these laws as they're stated above, we need to assume:

+ we are describing the physics in an inertial coord. system
+ again, developed for point masses (or, equivalently, COM coordinates)

Friction:



~ Typically, $\mu_k \le \mu_s$

Springs: $\vec{F} = -k\Delta x\,\hat{\imath}$

Gravity: $\vec{F}_g = -\frac{GmM}{r^2}\hat{r} \longrightarrow mg$ ← pos. or neg. depending on coord. system

near surface ~~center~~ of earth

Circular motion: $a_c = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$ ← period

ex/ Quiz 2, problem 3

Quiz 2, problem 5

Quiz 3, problem 2

III. Energy

$E = PE + KE$ = "total mechanical energy"

$\underbrace{PE \equiv U}_{\text{different notation you may see for PE}}$ & $\underbrace{KE \equiv K \equiv T}_{\text{different notation you may see for KE}}$

Some facts...

(1) $U_{spring} = \frac{1}{2}kx^2$

(2) $U_{gravity} = mgh$ ← near surface of earth

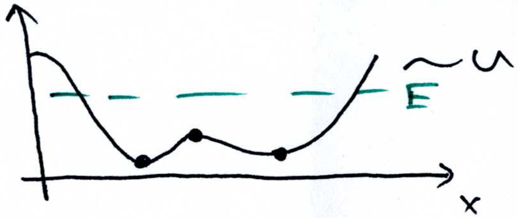
(3) $work \equiv \int \vec{F} \cdot d\vec{x} = \int \vec{F} \cdot \vec{v}\, dt = \Delta KE$

(4) $\vec{F} = -\frac{dU}{dx}\hat{x}$

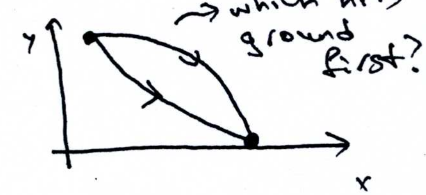
(5) $Power \equiv \frac{dE}{dt} = \frac{dW}{dt} = \vec{F} \cdot \vec{v}$

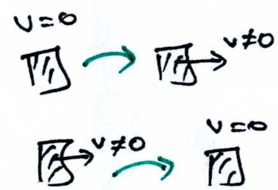
(6) $U_{gravity} = -\frac{GmM_E}{r}$ ← in general

ex



ex





~ work pos. or neg.?

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How does KE_1 compare to KE_2?

ex Quiz #3 problem 1 ~ if time

Momentum & COM

$\vec{p} = m\vec{v}$ ~ is conserved if $\Sigma \vec{F}_{ext} = 0$.

A few more facts...

(1) $\Delta\vec{p} = \Sigma \vec{F}_{ext}\, \Delta t \rightarrow \int \vec{F}_{ext}\, dt$

(2) $\vec{F} = \frac{\Delta \vec{p}}{\Delta t}$

(3) $KE = \frac{p^2}{2m}$

(4) $M\vec{a}_{com} = \Sigma \vec{F}_{ext}$

Collisions → elastic ($\Delta KE = 0$)

→ inelastic ($\Delta KE \neq 0$)

momentum conserved in either case so long as $\Sigma \vec{F}_{ext} = 0$.

Elastic collisions are roughly when things bounce off one another.

Inelastic collisions are when they stick together.

COM: $\vec{r}_{com} = \frac{\Sigma m_i \vec{r}_i}{\Sigma m_i} \rightarrow \frac{\int \vec{r}\, dm}{\int dm}$

The integrals simplify if we already know $\vec{r}_1^{\,com}$ & $\vec{r}_2^{\,com}$ for 2 distributions. In this case,

$$\vec{r}_{com} = \frac{m_1 \vec{r}_1^{\,com} + m_2 \vec{r}_2^{\,com}}{m_1 + m_2}$$

Rotations

moment of inertia: $I = \Sigma m_i r_i^2 \rightarrow \int r^2\, dm$

Here, r is measured from the axis of rotation.

In general $I = \eta M L^2$, where η is some constant dependent on the geometry of the problem.

Parallel axis theorem: $I = I_{com} + MR^2$, $R \equiv$ dist. from com to new axis of rotation.

Angular momentum:

$\vec{L} = I\vec{\omega} = \vec{r} \times \vec{p}$

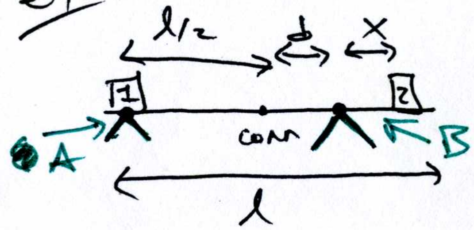
↳ conserved when $\vec{\tau}_{net} = 0$

Torque:

$\vec{\tau}_{net} = I\vec{\alpha} = \vec{r} \times \vec{F} = \frac{d\vec{L}}{dt}$

Torque acts @ com of objects.

ex



Find x so that $N_A = 0$

rotating forces = F_g, F_{g1}, F_{g2}, N_A