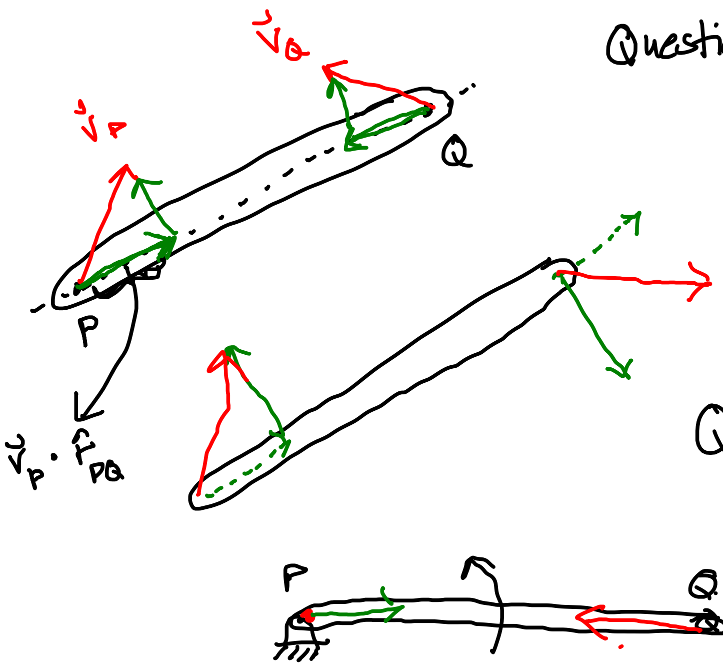
Review Problem PL 6-18 Possible Accelerations for two points

$\vec r_P =$ ____________

$\vec r_Q =$ ____________

$\vec a_P =$ ____________

possible $\vec a_Q$



Question 1: possible velocities

require: $\boxed{\vec v_P \cdot \hat r_{PQ}} = \vec v_Q \cdot \hat r_{PQ}$

$$\boxed{\Delta \vec v \cdot \hat r_{PQ} = 0}$$

$\vec v_Q - \vec v_P = \Delta \vec v$

~~Question~~

Question 2: possible accelerations

$$\boxed{\Delta \vec a \cdot \hat r_{PQ} = (\vec a_Q - \vec a_P)\cdot \hat r_{PQ} \le 0}$$ ✓

Class 31

$$\boxed{\vec{F} = m\vec{a}}$$ Newton's Law of Motion

What the $\vec{F}$?

so far in this class: Kinematics

Kinetics

description of the relationship between the motion $(\vec{r}, \vec{v}, \vec{a})$ and the forces that cause it

How do we prove $\vec{F} = m\vec{a}$?

We don't. It is a model. An empirical observation that seems to describe properly things that slow, light, relatively large.

Otherwise we'd need a different model.

ie) massive, fast $\Longrightarrow$ GENERAL RELATIVITY

sun, muon

ie) small (electrons, nuclei) $\Longrightarrow$ QUANTUM MECHANICS

ie) slow, light, large $\Longrightarrow$ CLASSICAL MECHANICS (Newton)

ie) small & massive $\Longrightarrow$?? no widely accepted theory

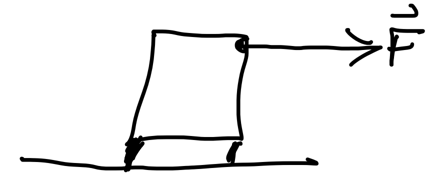
eg) blackholes, big bang

"quantum gravity"

"string theory"

"theory of everything"

George Box: "All models are wrong.
Some models are useful."



$\vec{F} = m\vec{a}$: 2 ways to use

① Method of Assumed Forces

assume $\vec{F}$ $\Longrightarrow$ calculate $\vec{a}$ $\Longrightarrow$ integrate $\vec{v}, \vec{r}$

② Method of Assumed Motion

assume the trajectory $\vec{r}$ $\Longrightarrow$ differentiate $\vec{v}, \vec{a}$ $\Longrightarrow$ calculate $\vec{F}$

How to apply $\vec{F} = m\vec{a}$

(A) Free Body Diagram

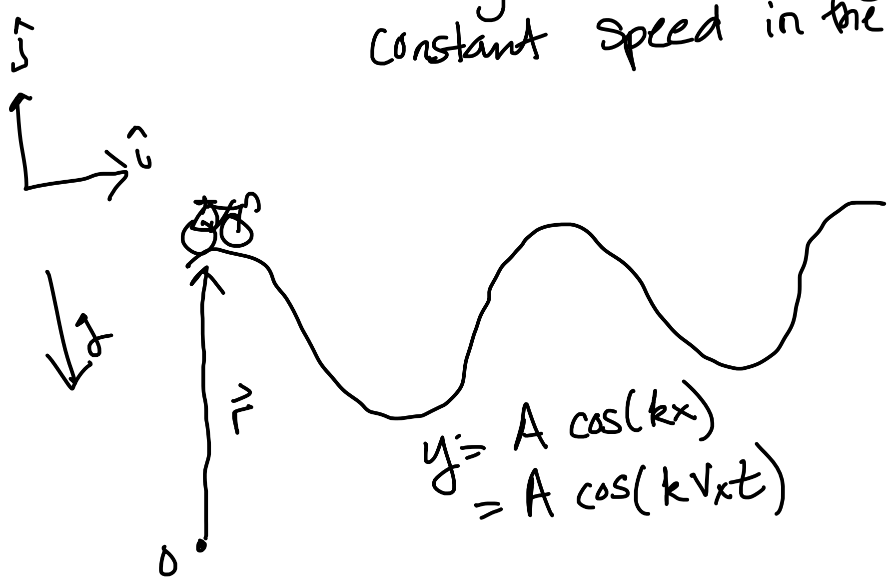
(B) Kinematics

(C) Newton's Law

(D) Algebra

Ex) Method of Assumed Motion:

A bicycle travels along a path $y(x) = A\cos kx$, with constant speed in the $\hat{i}$ direction ($\underline{V_x}$ = constant). There is gravity. What is the force of the road on the bicycle?



$y = A\cos(kx)$
$= A\cos(kV_x t)$

i-clicker:

A) $F = mg$

B) $F < mg$

C) $F > mg$

D) it depends.

$\underline{x = V_x t}$

step 1) assume motion $\vec{r} = x\hat{i} + y\hat{j}$

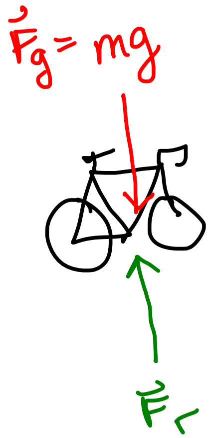
$\vec{r} = (V_x t)\hat{i} + A\cos(kV_x t)\hat{j}$

$$\vec{v} = \cancel{v_x \hat{i}} + A(-kv_x)\sin(kv_x t)\,\hat{j}$$

$$\vec{a} = -Ak^2 v_x^2 \cos(kv_x t)\,\hat{j}$$

Next step: $\vec{F} = m\vec{a}$

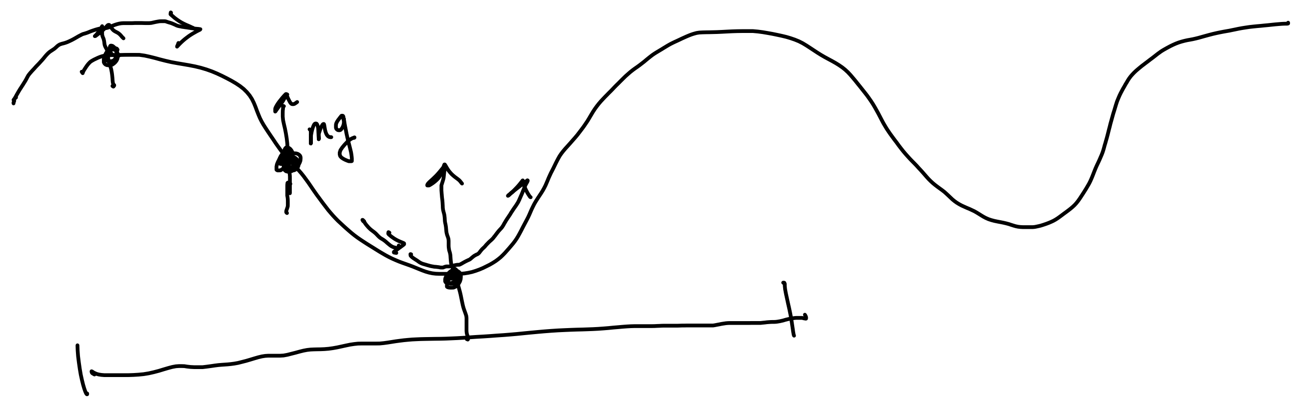
$$\vec{F} = \underline{-mk^2 v_x^2 A \cos(kv_x t)}\,\hat{j}$$

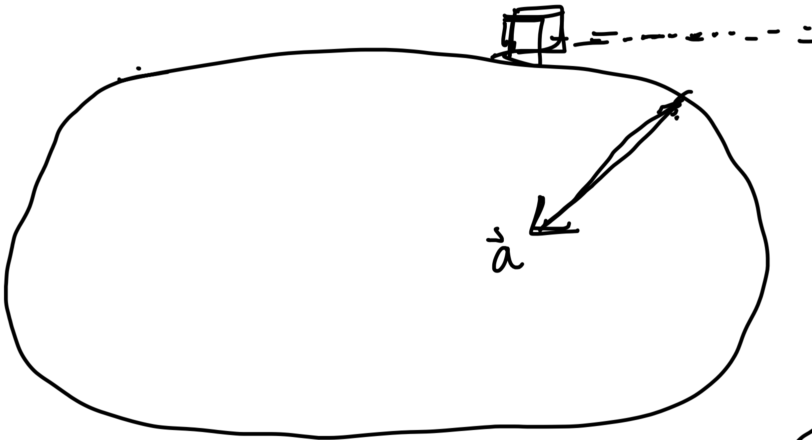


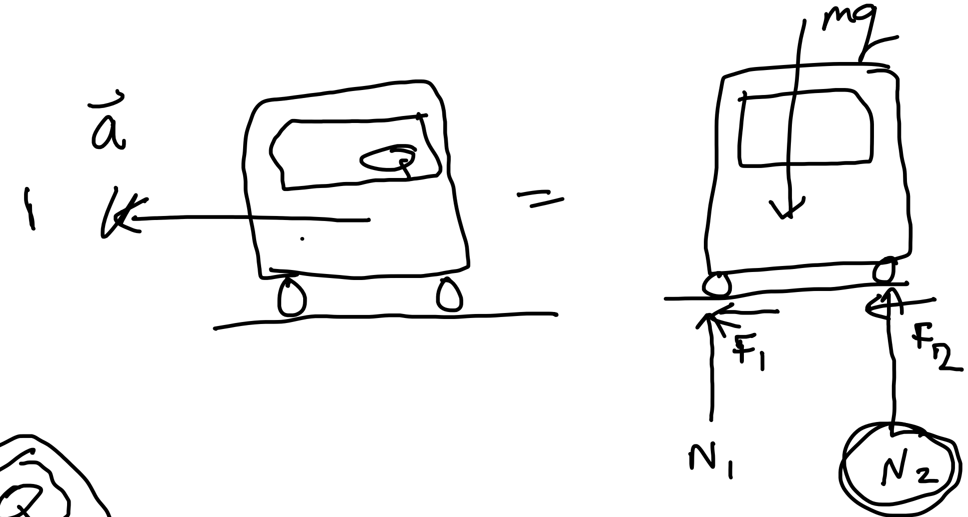
$$\vec{F} = \vec{F}_g + \vec{F}_r$$

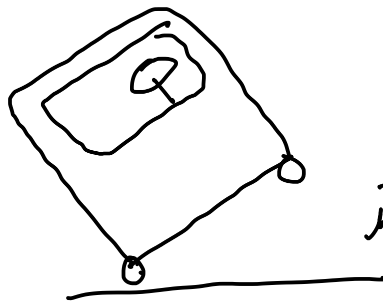
$$= -mg\hat{j} + \vec{F}_r = -mk^2 v_x^2 A \cos(kv_x t)$$

$$\vec{F}_r = \left[\underline{mg} - m(kv_x)^2 A \cos(kv_x t)\right]\hat{j}$$









if $N_2 < 0$