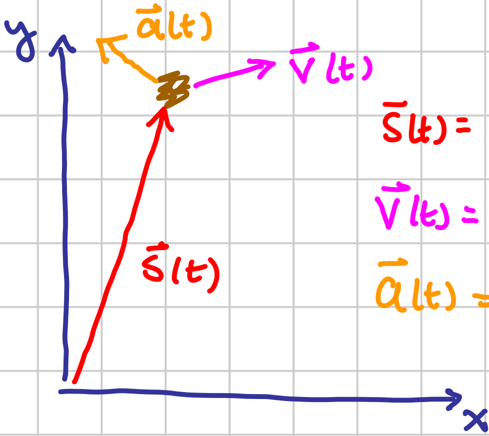
Physics 113 – September 20, 2012

- 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

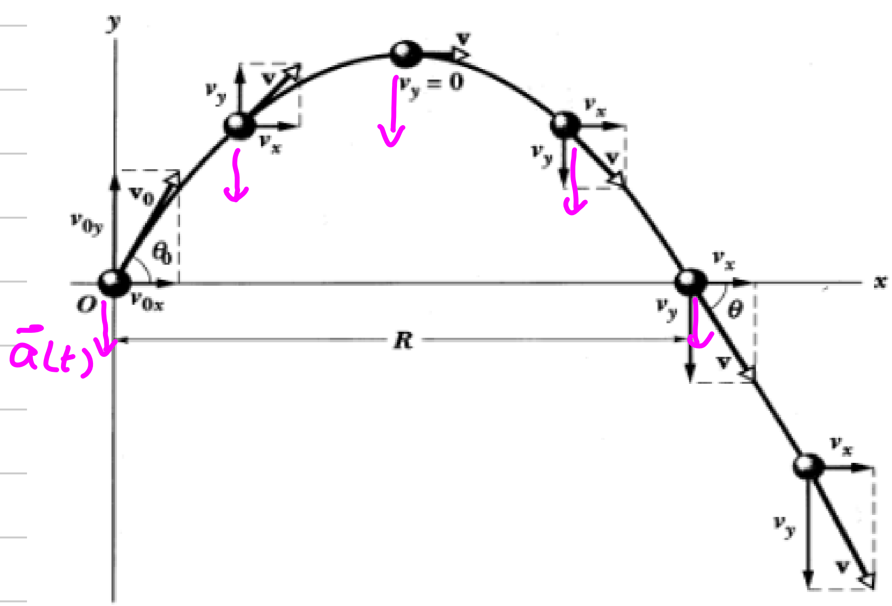


$$\vec{s}(t) = s_x \hat{i} + s_y \hat{j} + s_z \hat{k}$$

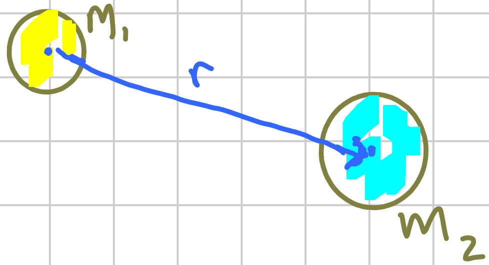
$$\vec{v}(t) = v_x \hat{i} + v_y \hat{j} + v_z \hat{k}$$

$$\vec{a}(t) = a_x \hat{i} + a_y \hat{j} + a_z \hat{k}$$

Projectile Motion



Newton's Law of Gravitation

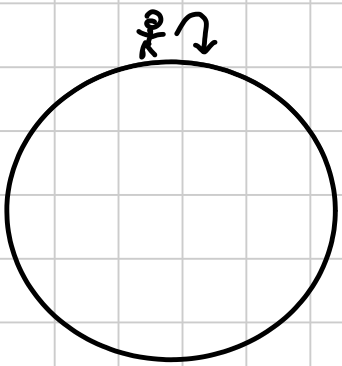


$$F = \frac{G m_1 m_2}{r^2}$$

$$\vec{F} = -\frac{G m_1 m_2}{r^2}\hat{r}$$

Attractive Force

Along the line joining masses



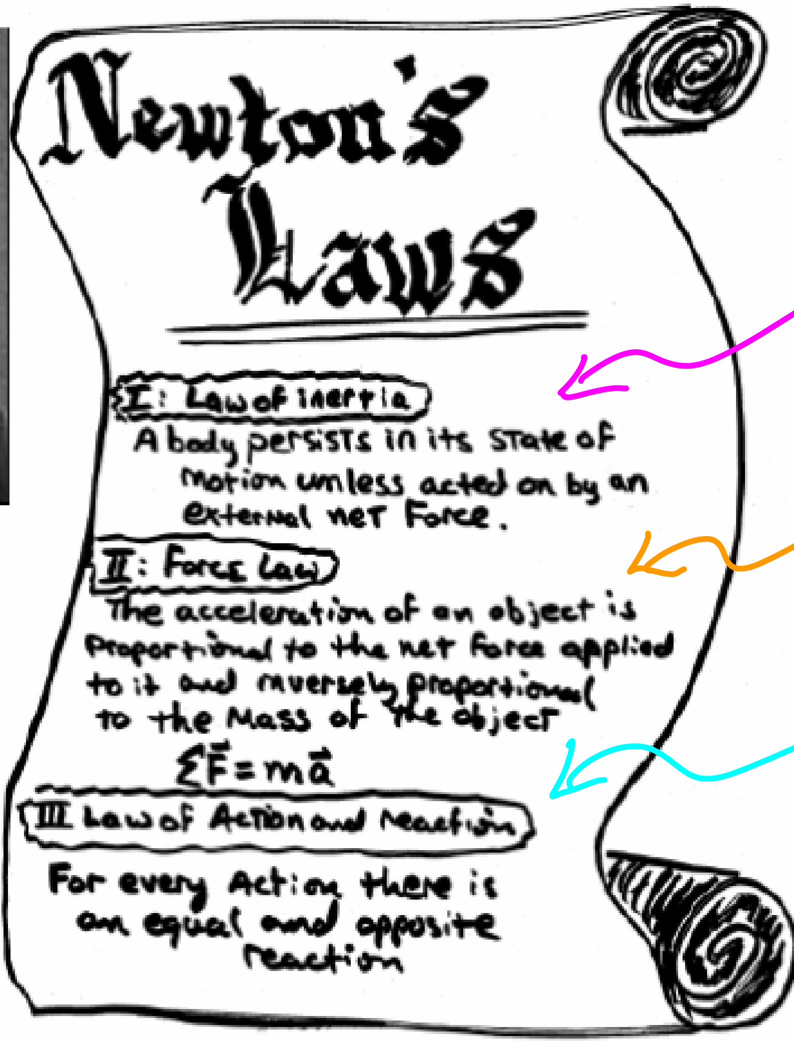
At Surface of Earth

$$F = \frac{G M_{earth}}{r_{earth}^2} m$$

$g = 9.8\ m/s^2$

$F = ma$

$F = mg$



(ice skater)

(pushing a car)

(recoil of gun)

Vector equation $\sum \vec{F} = m\vec{a}$

Equivalent to 3 one-dim equations

$$\sum F_x = m a_x$$

$$\sum F_y = m a_y$$

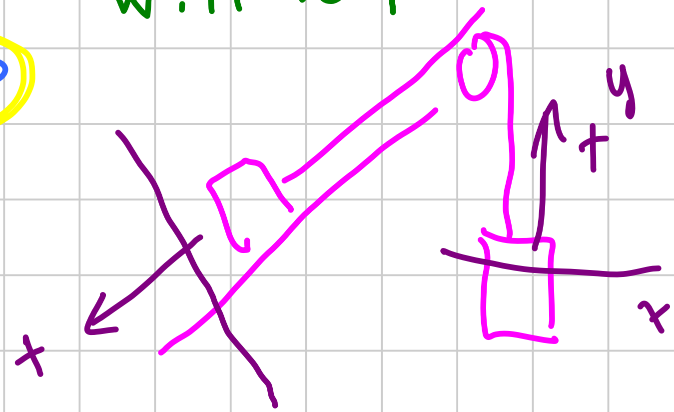
$$\sum F_z = m a_z$$

The Path to Enlightenment

1. understand Problem, Draw Neat diagram of overall problem
2. draw Free body diagram of ~~all~~ each relevant object – label with forces
3. Choose convenient coordinate system for each object
4. Apply Newton's Second Law $\Sigma\vec{F} = m\vec{a}$ in appropriate orthogonal coordinates (coordinates chosen for each body must be related to those chosen for other bodies)
5. Keeping Symbols in place (No #'s yet!) Solve resulting Set of equations Simultaneously.
6. Check answer with limiting cases and dimensional Analysis!

Neat FBD's will help

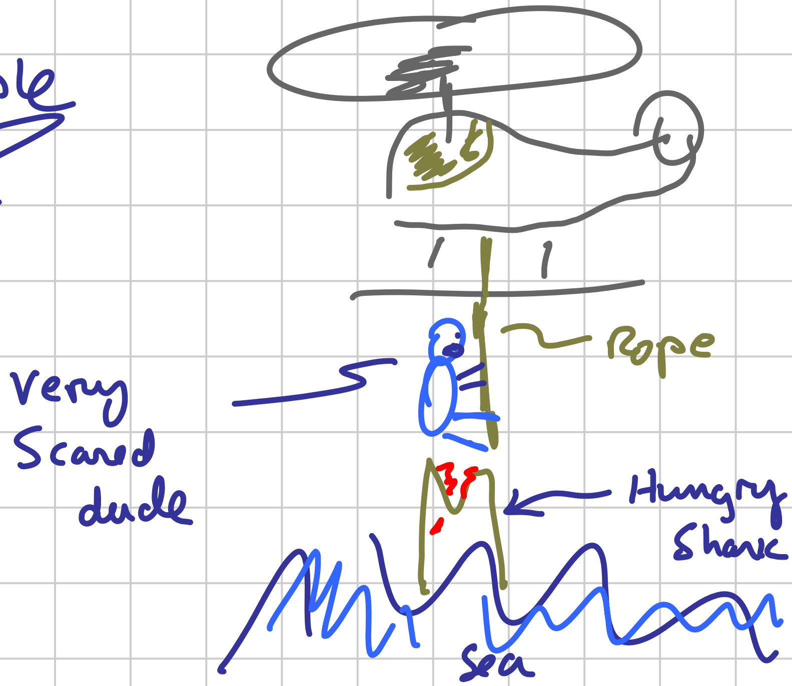
FBD



Sketched in response to question about coords for each Diagram having to be the same

go Slow + Systematically

Example

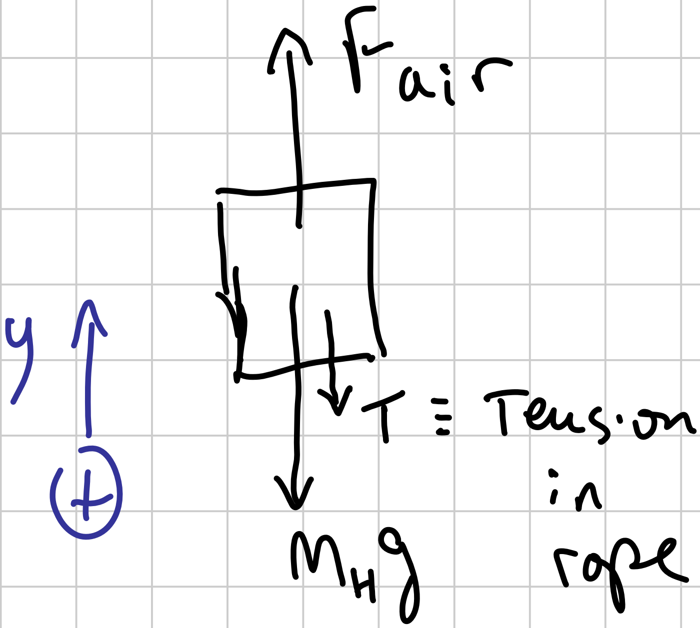


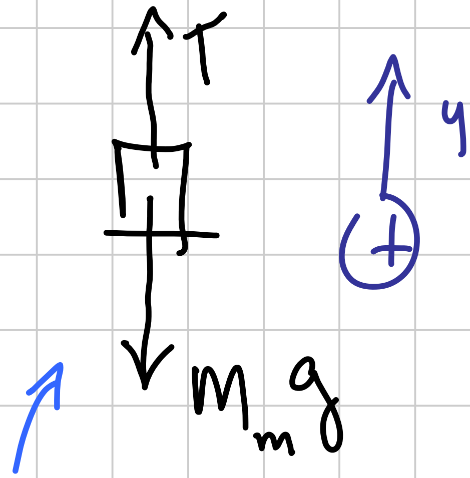
Man has mass 70 kg

Helicopter

Accelerates upward at $4\,m/s^2$

What Tension must rope withstand?





Newtons

$F = ma$

$kg\,m/s^2$

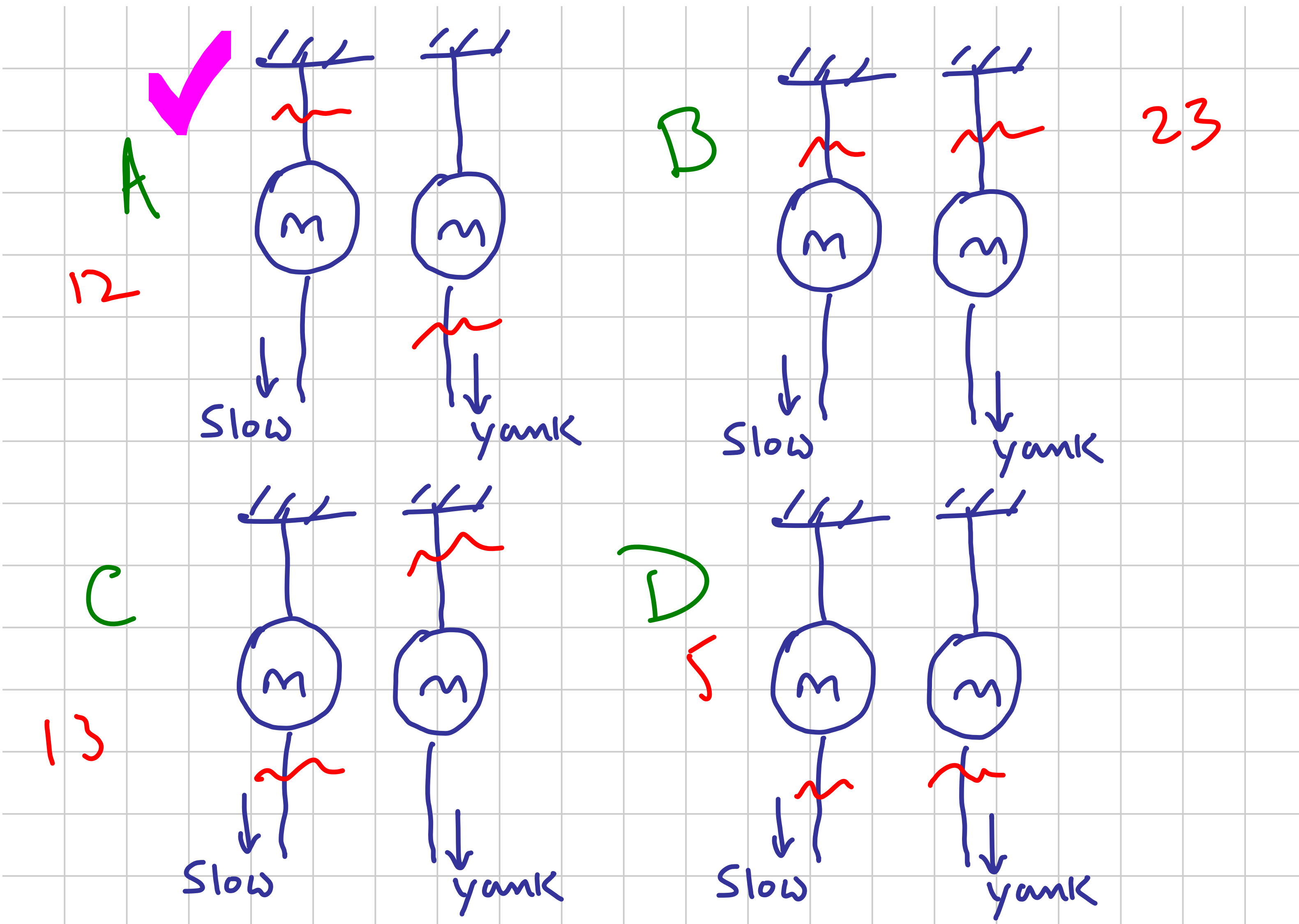
$$\sum F_y = T - M_m g = M_m a$$

70 9.8 70 4

$$T - m_m g = m_m a$$

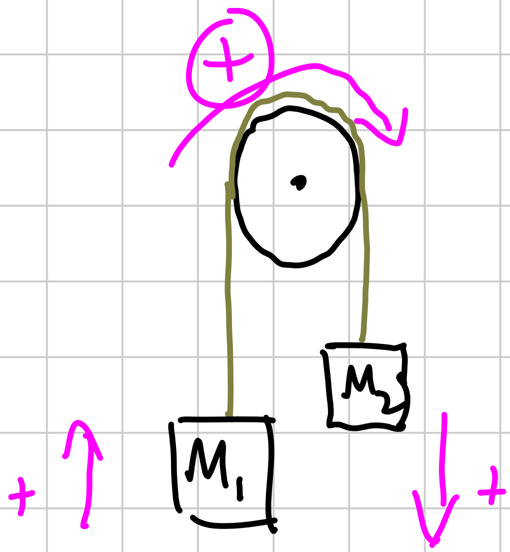
$$T = m_m (a + g) = 466 \text{ Newtons}$$

m_m ↑ 70 a ↑ 4 g ↑ 9.8


A
12
m
m
Slow
yank
B
23
m
m
Slow
yank
C
13
m
m
Slow
yank
D
5
m
m
Slow
yank

Example

Atwood's Machine

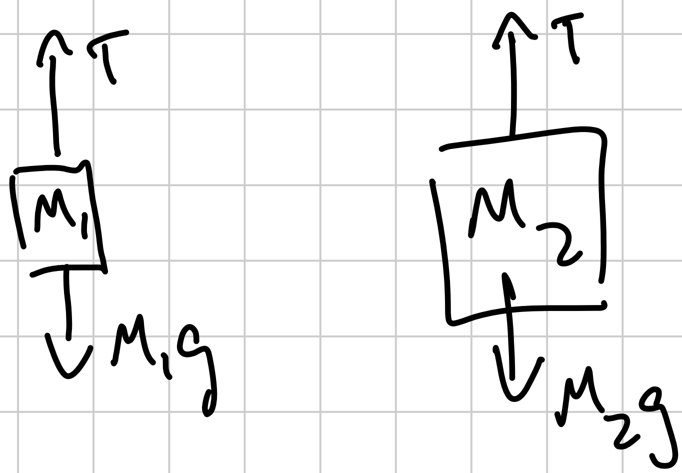


Massless Frictionless Pulley

$M_1 = 6$ kg

$M_2 = 10$ kg

Syst at rest is released
What is the acceleration of the system?



$\Sigma F_y = M_1 a = T - M_1 g$ $\quad$ $\Sigma F_y = M_2 a = -T + M_2 g$

N eqns , N unknowns → can solve
(2) $\quad$ (2)

$$a = \left(\frac{M_2 - M_1}{M_1 + M_2} \right) g$$

check limiting cases

- M_1 big
- M_2 big

$$T = M_2 \left(g - \frac{M_2 g - M_1 g}{M_1 + M_2} \right)$$

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

check units