Ch. 5 Force and Motion

100 Fletcher-Argue
1:30 M, W

② $\Sigma \vec{F} = m\vec{a}$

① if $\Sigma \vec{F} = 0$, $\vec{v}$ constant

③ $\vec{F}_{AB} = -\vec{F}_{BA}$

Newton's Laws.

on A
from B

$F_g = mg$ $\quad g = 9.8 m/s^2$

Free body diagrams
3rd Law pairs.

Some types of forces:

gravity
normal
Friction
tension
weight (mag. needed to keep from falling freely)

$W - F_g = m(0)$

$W = F_g$ if inertial.

Work problems

centripetal force

① inclined plane.
② block on plane.
③ elevator
④ plane in dives.

Wednesday - start Ch. 6 ~~if need to~~. can continue examples if need to

Tutorial test R, F.

Solving problems
① Draw picture / define coord.
② Draw free-body diagrams
③ Gather knowns
- Givens
- Newton's Laws
- Algebra / trig / calc / geo

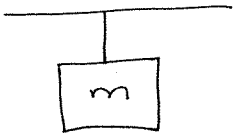
④ Write system of eqns
⑤ Solve system
⑥ Plug in numbers

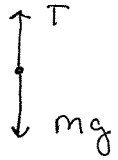
Some basic items:

block
rope
pulley
inclined plane } simple machines

Neglect friction, air resistance for now

Example s!

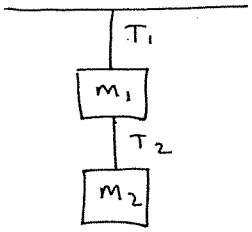


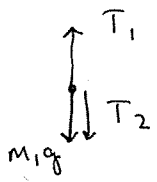


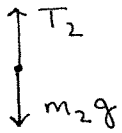
$\Sigma F_y = 0$

$T - mg = 0$

$T = mg$



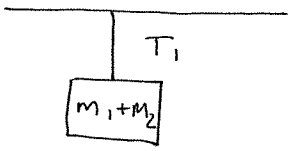




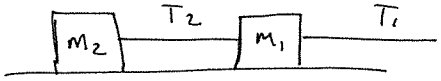
$T_2 = m_2 g$

$T_1 = m_1 g + T_2$

$= (m_1 + m_2) g$

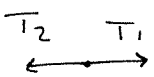


internal forces cancel

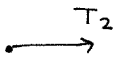


Can ignore T_2 in "system"

$$T_1 = (m_1 + m_2)\,a$$



$$T_1 - T_2 = m_1 a$$



$$T_2 = m_2 a$$

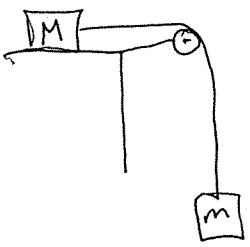
$$\Rightarrow \quad T_1 - m_2 a = m_1 a$$

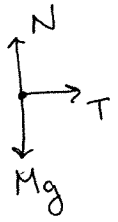
$$T_1 = (m_1 + m_2)\,a \quad \checkmark$$

3rd Law Pairs

$$\vec{F}_{AB} = -\vec{F}_{BA}$$

never appear on same object.

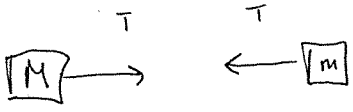




Pulley changes direction.

ΣF_y $\qquad$ ΣF_y

ΣF_x $\qquad$ ΣF_x

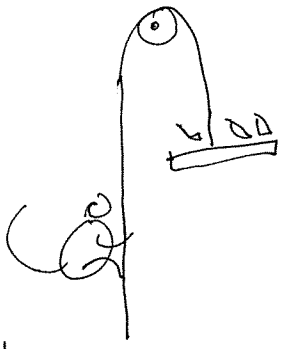


Don't need to consider internal forces!

Problem 5b

$m_1 = 10\,kg$

$m_2 = 15\,kg$



$m_1 = m_2$

system initially at rest

Can Monkey climb to reach bananas?

$T - mg = a_m$

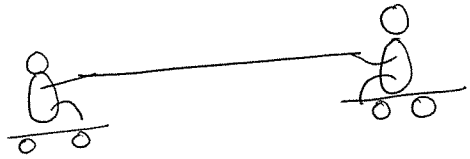
$T - mg = a_b$

$\Rightarrow \quad a_m = a_b$

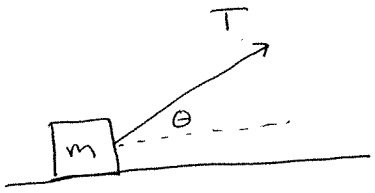
As rope shortens, monkey and bananas both move towards pulley?

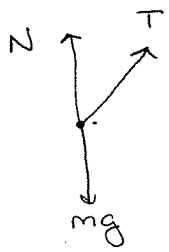
Tension in rope cancels.

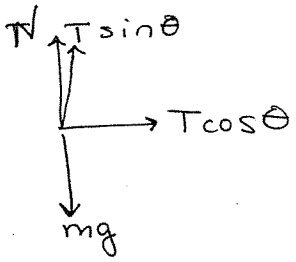
Straighten out:



Doesn't matter who pulls.
Rope gets shorter.







$$\Sigma F_x = T\cos\theta = ma_x$$

$$a_x = \frac{T\cos\theta}{m}$$

$$\Sigma F_y = N + T\sin\theta - mg = 0$$

$\theta = 30°$
$T = 100\ N$
$m = 80\ kg$

v after 2m?
initially at rest

$$a_x = \frac{(100)\cos 30°}{80} = 1.08\ m/s^2$$

$$v_x^2 = v_{ox}^2 + 2a_x\Delta x$$

$$v_x = \sqrt{2(1.08)(2)} = 2.08\ m/s$$

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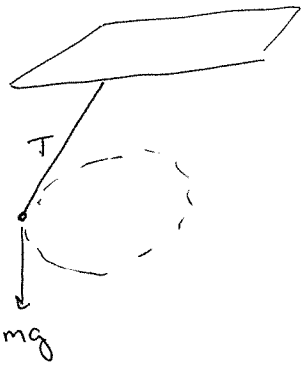
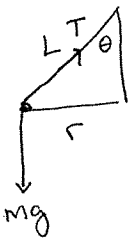
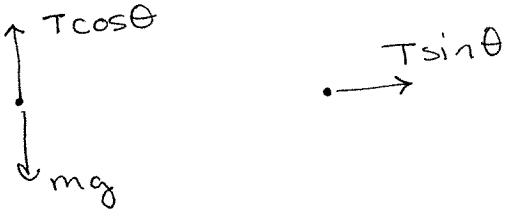
to move in constant ~~radius~~ speed v
~~circle~~.





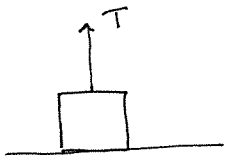
$r = L\sin\theta$

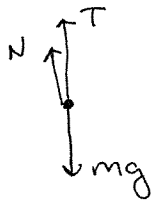


$$\Sigma F_y = T\cos\theta - mg = 0$$

$$\Sigma F_x = T\sin\theta = m\frac{v^2}{r}$$

$$\tan\theta = \frac{v^2}{gr}$$





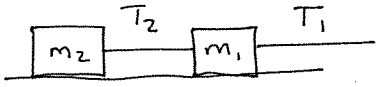
$\Sigma F = 0$

$T + N = mg$

$N = mg - T$

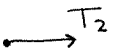
$= (10kg)(9.8m/s^2) - 40N$

$= 58N$



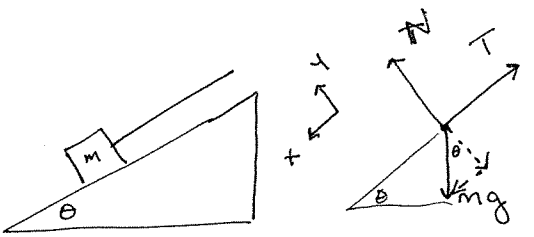
$T_1 = (m_2 + m_1)\,a$

$a = \dfrac{T_1}{m_2 + m_1} = \dfrac{40N}{12kg + 10kg} = 1.82\,m/s^2$



$T_2 = ma$

$= (12kg)(1.82m/s^2) = 21.82\,N$



$N - mg\overset{\cos}{\cancel{\sin}}\theta = 0$ (y-dir)

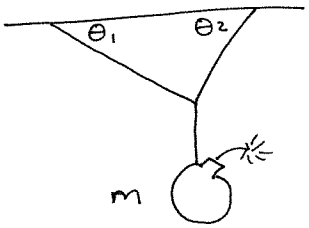
$T - mg\overset{\sin}{\cancel{\cos}}\theta = 0$ (x-dir)

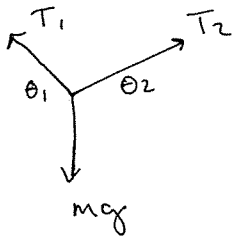
$a = 0$

cut cord: $N - mg\overset{\cos}{\cancel{\sin}}\theta = 0$ (y-dir)

$-mg\sin\theta = ma_x$ (x-dir)

$a_x = -g\sin\theta$



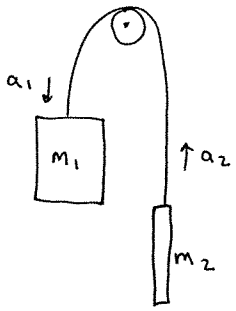


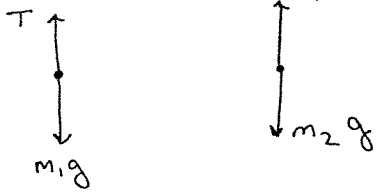
equilibrium:
$\Sigma F = 0$

y-dir $T_1 \sin\theta_1 + T_2 \sin\theta_2 = mg$

x-dir $-T_1 \cos\theta_1 + T_2 \cos\theta_2 = 0$

Atwood's Machine





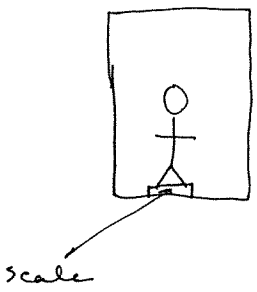
$T - m_1 g = a_1$

$T - m_2 g = a_2$

$a_1 = -a_2$

$\searrow (m_1 - m_2)g = a$

Inside elevator (non-inertial frame)



If v constant, $a = 0 \rightarrow \Sigma F = 0$

$\Sigma F_y = N - mg = 0$

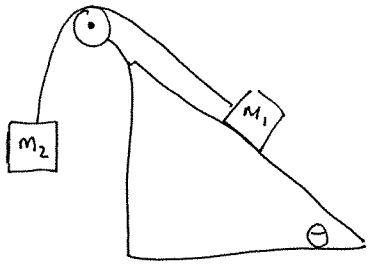
$\therefore N = mg$

If slowing down ($a < 0$)

$N - mg = ma$

$N = m(g + a)$ a neg $\Rightarrow$ scale reads light!

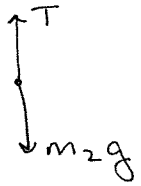
Example

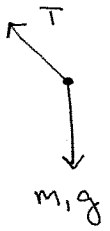


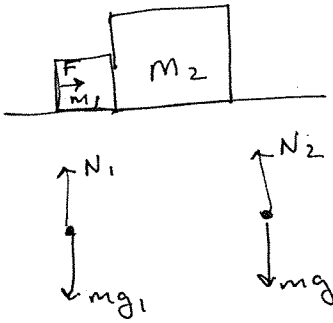
which way?

$a = ?$

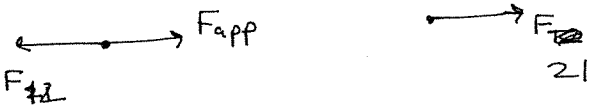
$T = ?$







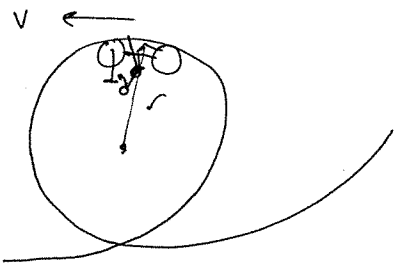
F_{CE} on 64

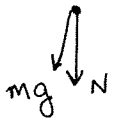


$F_{app} = (m_1 + m_2)a$

$a = \dfrac{F_{app}}{m_1 + m_2}$

$F_{app} - F_{21} \neq m_2 a$ $\quad F_{21} = m_2 a$





↓+y

$\Sigma F_y = N + mg = ma$ $\qquad a = \frac{v^2}{r}$

$N + mg = m\frac{v^2}{r}$

limit → $N = 0$ → slowest v to not fall.

$v = \sqrt{rg}$