06 DEC 11

- DAY 50

- HW ✓ & Q&A with WARM-UP
- Related Rates project parameters – questions?
- Table Cloth Demonstration → 2 ways
- Newton's 3rd Law
- Pulling a box at an angle
- The Normal Force (with Demonstrations) vs. WEIGHT
- Elevators: weight & hanging mass tension
- Connected Masses (vertical & horizontal)
- Homework Assignment

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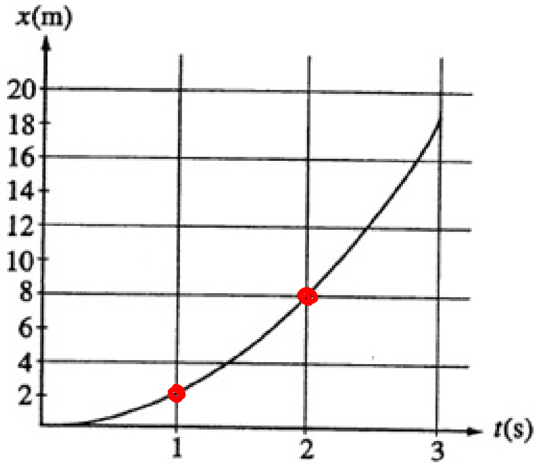
Warm-ups

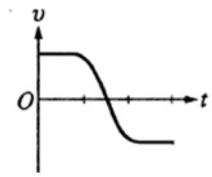
(1)



11. The graph above represents position x *versus* time t for an object being acted on by a constant force. The average speed during the interval between 1 s and 2 s is most nearly

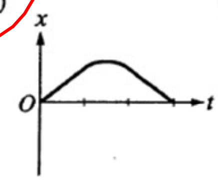
(A) 2 m/s
(B) 4 m/s
(C) 5 m/s
(D) 6 m/s
(E) 8 m/s

(2)

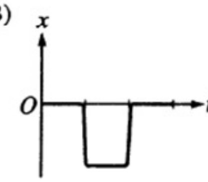


1. The graph above shows velocity v *versus* time t for an object in linear motion. Which of the following is a possible graph of position x *versus* time t for this object?

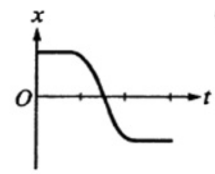
(A)



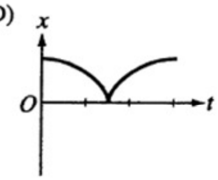
(B)



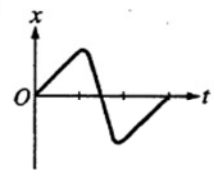
(C)



(D)



(E)



1. (I) What force is needed to accelerate a child on a sled (total mass = 60.0 kg) at $1.25\ \text{m/s}^2$?

$$F = ma$$
$$= (60\text{kg})(1.25\ \text{m/s}^2)$$
$$= \boxed{75\text{N}}$$

2. (I) A net force of 265 N accelerates a bike and rider at $2.30\ \text{m/s}^2$. What is the mass of the bike and rider together?

$$F = ma \Rightarrow m = \frac{F}{a} = \frac{265\text{N}}{2.3\ \text{m/s}^2}$$
$$= \boxed{115.217\ \text{kg}}$$

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4. (I) What is the weight of a 76-kg astronaut (*a*) on Earth, (*b*) on the Moon $\left(g = 1.7\ \text{m/s}^2 \right)$, (*c*) on Mars $\left(g = 3.7\ \text{m/s}^2 \right)$, (*d*) in outer space traveling with constant velocity?

(a) weight ⇒ $mg = (76\,kg)(9.8\,m/s^2) = \boxed{744.8\,N}$

(b) $mg = (76\,kg)(1.7\,m/s^2) = \boxed{129.2\,N}$

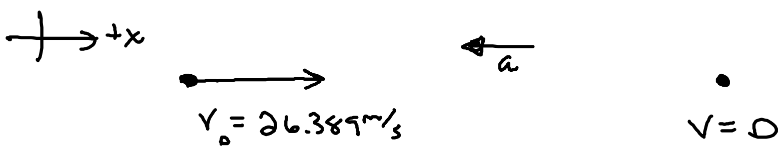
(c) $mg = (76\,kg)(3.7\,m/s^2) = \boxed{281.2\,N}$

(d) $mg = m(0) = \boxed{0\,N}$

☆ end of page

6. (II) What average force is required to stop an 1100-kg car in 8.0 s if the car is traveling at 95 km/h ?

$$95\,\frac{km}{h} \times \frac{1h}{3600s} \times \frac{1000m}{1km} = 26.389\,m/s$$



$$a = \frac{v - v_0}{t} = \frac{0 - 26.389\,m/s}{8s} = -3.299\,m/s^2$$

$$F = ma = (1{,}100kg)(-3.299\,m/s^2) = \boxed{-3628.9\,N}$$

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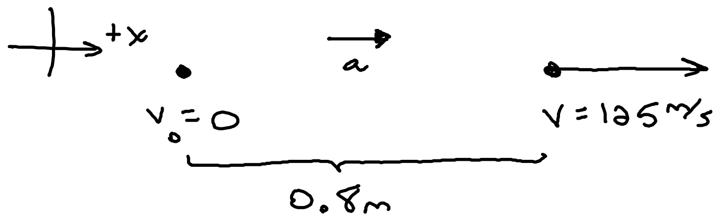
7. (II) What average force is needed to accelerate a 7.00-gram pellet from rest to 125 m/s over a distance of 0.800 m along the barrel of a rifle?

7 grams = 0.007 kg



$$a = \frac{v^2 - v_o^2}{2x} = \frac{(125 \, m/s)^2 - 0^2}{2(0.8m)} = 9{,}765.625 \, m/s^2$$

$$F = ma = (0.007kg)(9765.625 \, m/s^2) = \boxed{68.359N}$$

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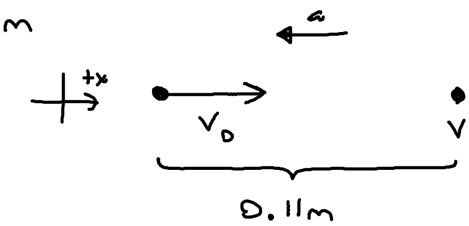
9. (II) A 0.140-kg baseball traveling 35.0 m/s strikes the catcher's mitt, which, in bringing the ball to rest, recoils backward 11.0 cm. What was the average force applied by the ball on the glove?

11 cm = 0.11 m

$v_0 = 35\,m/s$

$v = 0$

$m = 0.14\,kg$



$$a = \frac{v^2 - v_0^2}{2x} = \frac{0^2 - (35\,m/s)^2}{2(0.11\,m)} = -5{,}568.182\,m/s^2$$

$$F = ma = (0.14\,kg)(-5{,}568.182\,m/s^2) = \boxed{-779.545\,N}$$

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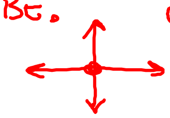
3. If the acceleration of an object is zero, are no forces acting on it? Explain.

MAYBE. many forces, but net force must be zero

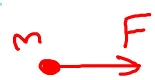


$\Sigma F = 0 \Rightarrow a = 0$

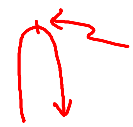
• if no forces, $F = 0 \Rightarrow a = 0$

4. Only one force acts on an object. Can the object have zero acceleration? Can it have zero velocity? Explain.

NO — MAYBE

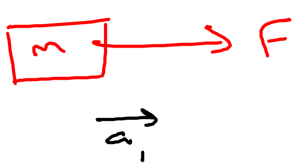


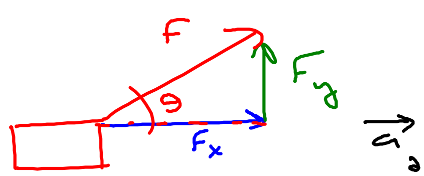
ball thrown up:



$v = 0$
$a \neq 0$

12. You pull a box with a constant force across a frictionless table using an attached rope held horizontally. If you now pull the rope with the same force at an angle to the horizontal (with the box remaining flat on the table), does the acceleration of the box (*a*) remain the same, (*b*) increase, or (*c*) decrease? Explain.





$F_x < F \therefore a_2 < a_1$

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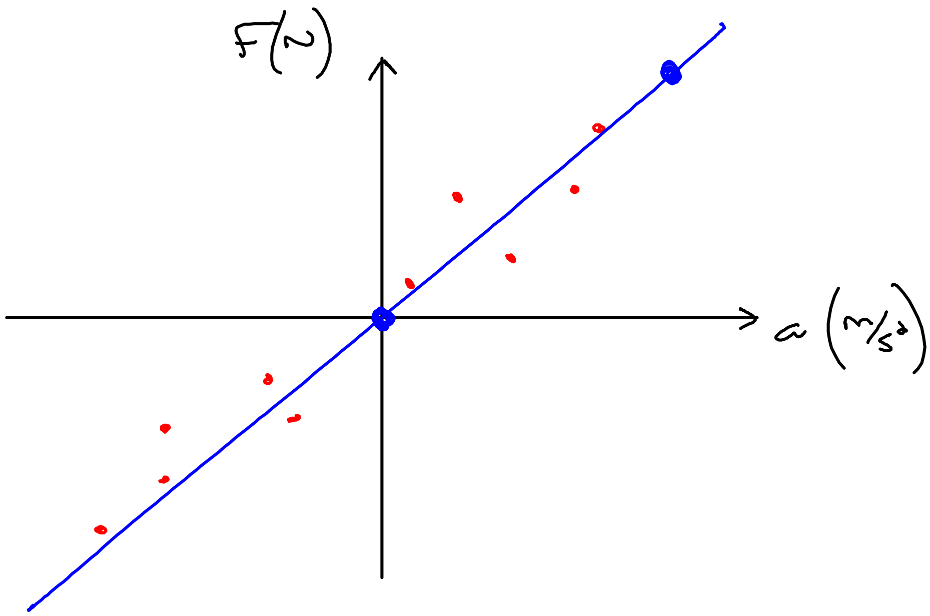
⇒ RELATED RATES poster project

- 8.5" × 11"
- title
- at least 1 picture & 1 labeled diagram
- a short problem statement/set-up paragraph
- show all work & calculations
- conclusion & interpretation of the answer
- make it "wall worthy"
- OTHER:

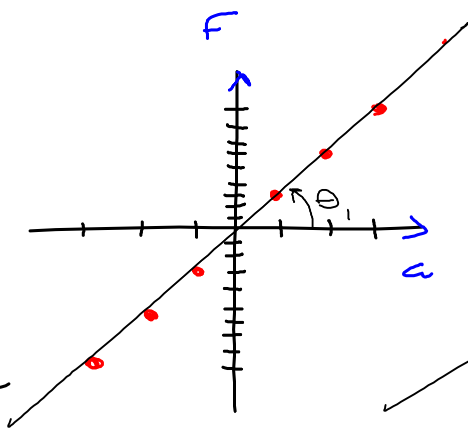
A non-zero net force CHANGES the velocity of an object.

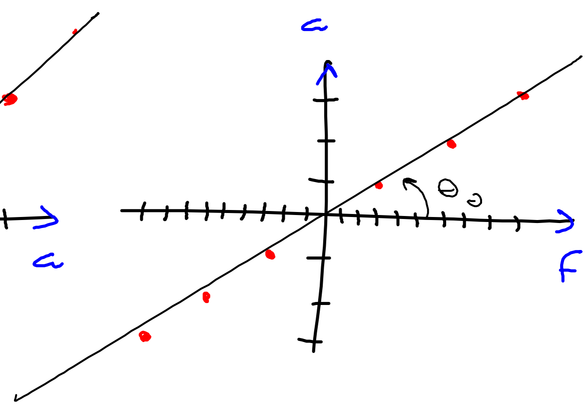


$F = ma \Rightarrow a = \frac{F}{m} = \frac{1}{m} F$

let $m = 3\,kg$

F	a
3	1
6	2
9	3
-3	-1
-6	-2
-9	-3





$m_1 = \frac{9 - -9}{3 - -3} = \frac{9}{3} = 3\,kg$

$\theta_1 > \theta_2$

$m_2 = \frac{3 - -3}{9 - -9} = \frac{3}{9} = \frac{1}{3}\,kg^{-1}$

$\frac{N}{m/s^2} = \frac{1\,kg\ m/s^2}{m/s^2}$

⇒ TABLE CLOTH DEMO:

- not only an inertia demo!
- also illustrates magnitude of force : time over which the force is applied.

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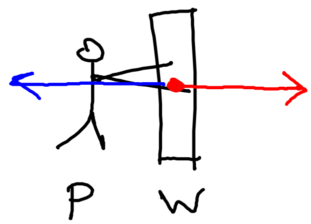
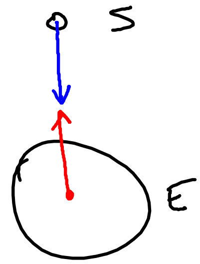
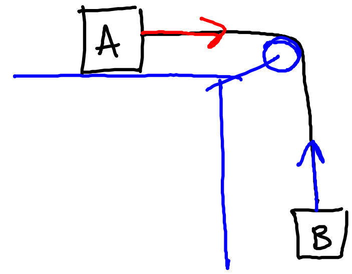
Newton's 3rd Law → connect all 3

notes3

action - reaction pairs







	CONTACT	GRAVITY	TENSION
magnitude:	$F_{WP} = F_{PW}$	$F_{SE} = F_{ES}$	$T_{AB} = T_{BA}$
direction:	$\vec{F}_{WP} = -\vec{F}_{PW}$	$\vec{F}_{SE} = -\vec{F}_{ES}$	$\vec{T}_{AB} = -\vec{T}_{BA}$

Statement of 3rd Law:

↓

When we examine a body, we are concerned with the forces acting **ON** that body.

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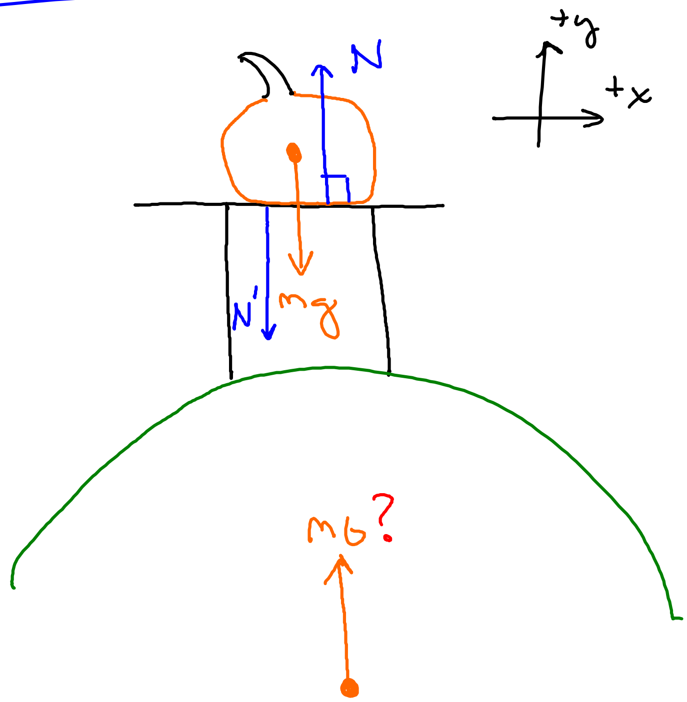
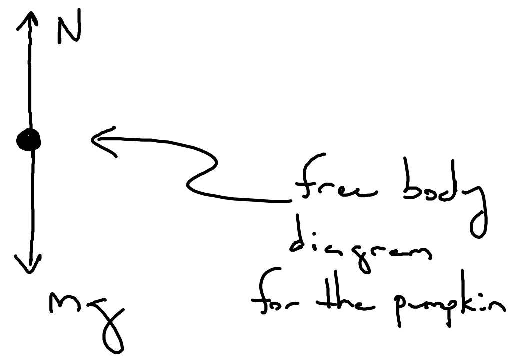
The 3rd Law & the Normal Force



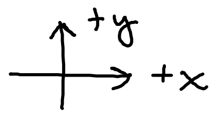


★ NORMAL means "perpendicular"

Problem Solving: some helpful hints

① draw a labeled picture

② Draw a free body diagram ⇐ A MUST!



③ resolve the forces into x & y components

④ find $\sum F_x$ & $\sum F_y$ being careful w/ direction

⑤ What's a_x & a_y?

⑥ algebra, algebra, algebra

⑦ does your answer make sense?

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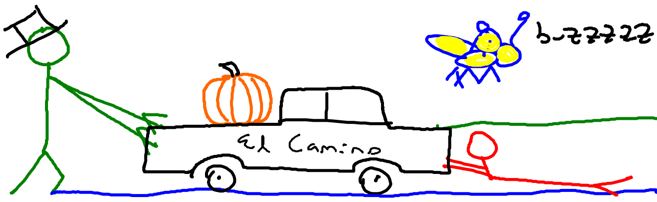
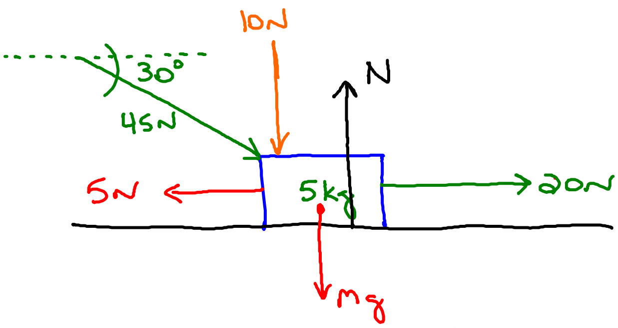


notes6

complicated?

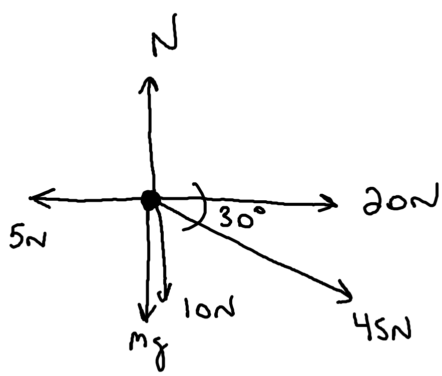
SIMPLIFY!

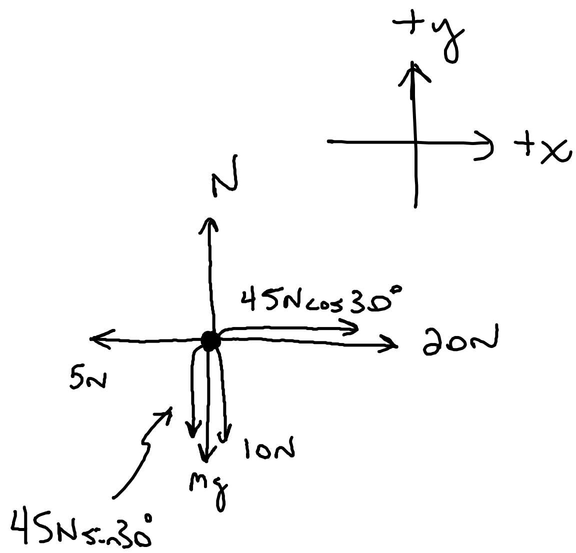


a crate is pushed on a level, frictionless surface.

*Don't forget weight & normal force

* Draw a free body diagram





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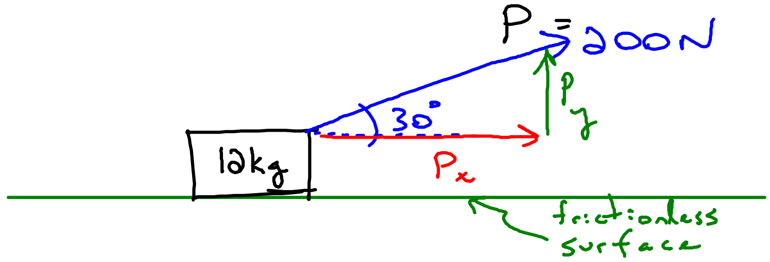
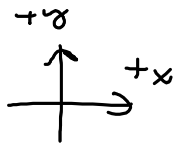
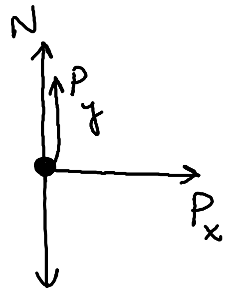
⇒ Pulling a Box







$$\sum F_y = N + P_y - mg$$

$$m a_y = N + P\sin\theta - mg \quad (a_y = 0)$$

$$N = mg - P\sin\theta$$

$$\sum F_x = P_x$$

$$m a_x = P\cos\theta \Rightarrow a_x = \frac{P\cos\theta}{m}$$

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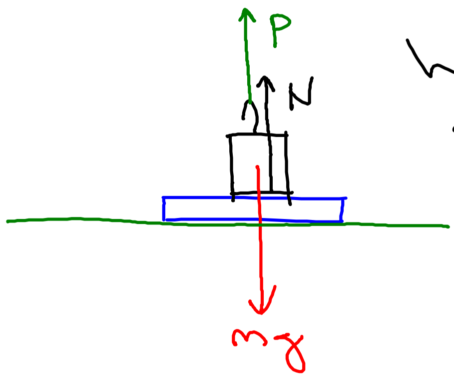
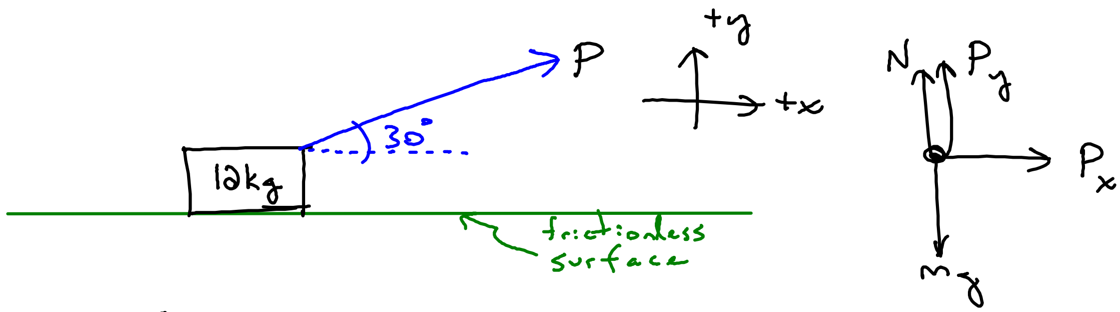
⇒ Demo: force plate & the normal force

Part One



What happens to N as P is increased?

⇒ for the previous example, find P such that m is "just about to rise off of the floor"



$$\Sigma F_y = N + P_y - mg$$

$$0 \; \cancel{\Sigma ma_y} = \cancel{N}^{0} + P\sin\theta - mg \Rightarrow P\sin\theta = mg$$

$$P = \frac{mg}{\sin\theta}$$

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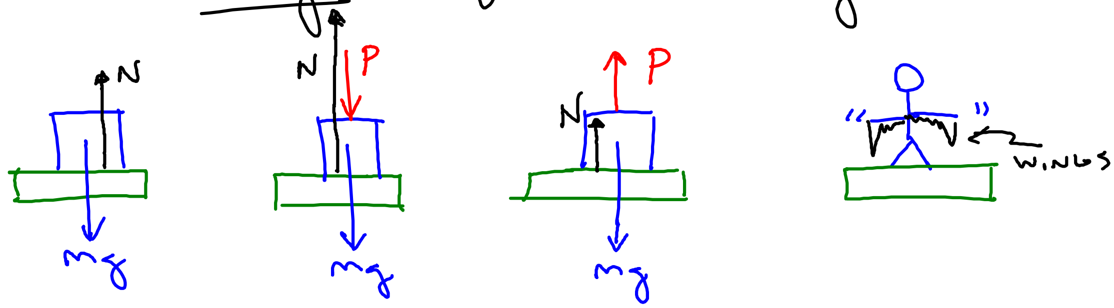
- Demo: Force plate & the normal force II

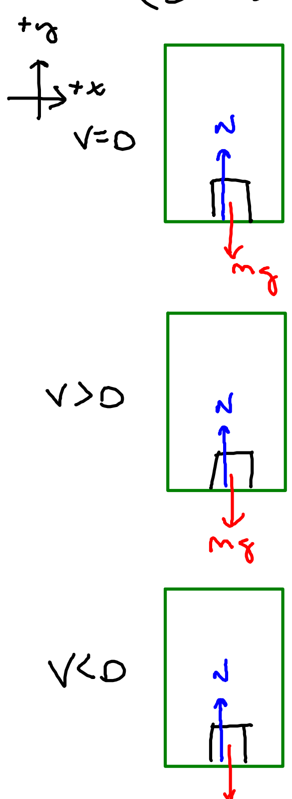
On flat ground, the normal force does not always equal the weight



- Demo: Force plate & the normal force III

How does acceleration affect the weight? the normal force?

a = 0 (3 cases)



$\sum F = N - mg$

$0 = N - mg \Rightarrow N = mg$

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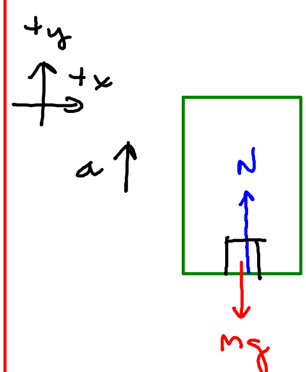
a > 0



$\sum F = N - mg$

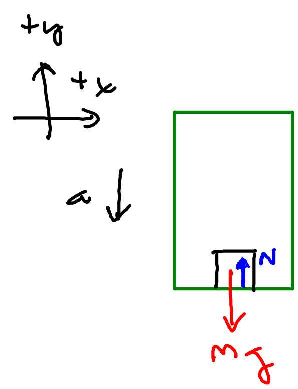
$+ma = N - mg$

$N = mg + ma$

$N = m(g + a)$

$\therefore N > mg$

a < 0



$\sum F = N - mg$

$-ma = N - mg$

$N = mg - ma$

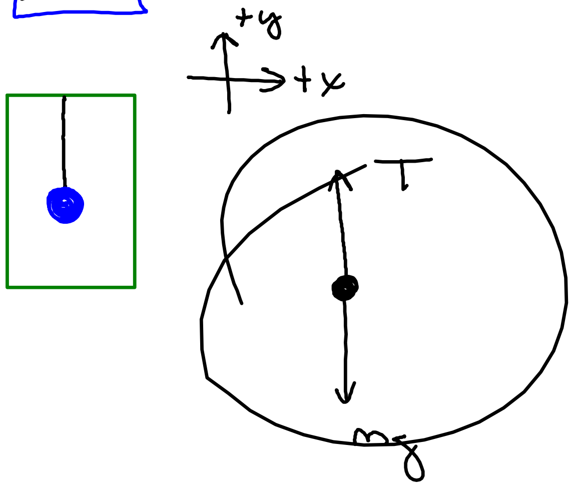
$N = m(g - a)$

$\therefore N < mg$

⇒ Object hanging by a string (2 cases)

for both, discuss possible velocities

a = 0



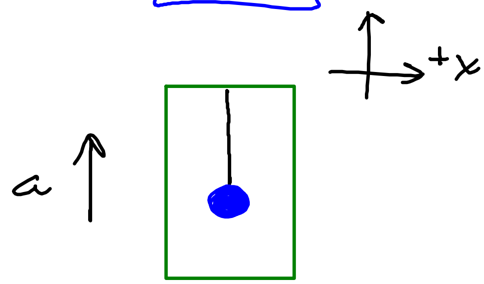
$$\sum F = T - mg$$

$$\cancel{ma} = T - mg \quad (ma = 0)$$

$$0 = T - mg$$

$$T = mg$$

a > 0



$$\sum F = T - mg$$

$$+ma = T - mg$$

$$T = mg + ma$$

$$= m(g + a)$$

* Also, consider the tension if $a < 0$.

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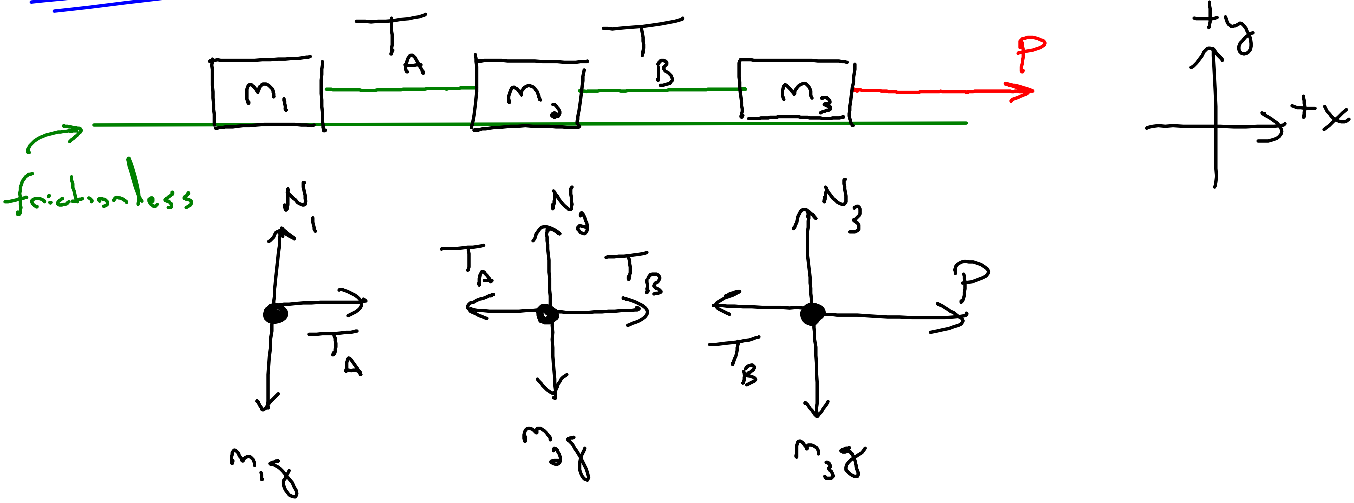
⇒ Multiple Masses connected by a "string"

* "string" for these problems is "massless"

HORIZONTAL CASE



m_1: $\sum F_x = T_A$

$$\boxed{m_1 a = T_A}$$

m_2: $\sum F_x = T_B - T_A$

$$\boxed{m_2 a = T_B - T_A}$$

m_3: $\sum F_x = P - T_B$

$$\boxed{m_3 a = P - T_B}$$

$$m_1 a + m_2 a + m_3 a = P$$

$$(m_1 + m_2 + m_3)\, a = P$$

$$a = \frac{P}{m_1 + m_2 + m_3}$$

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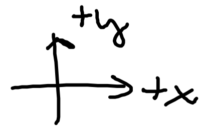
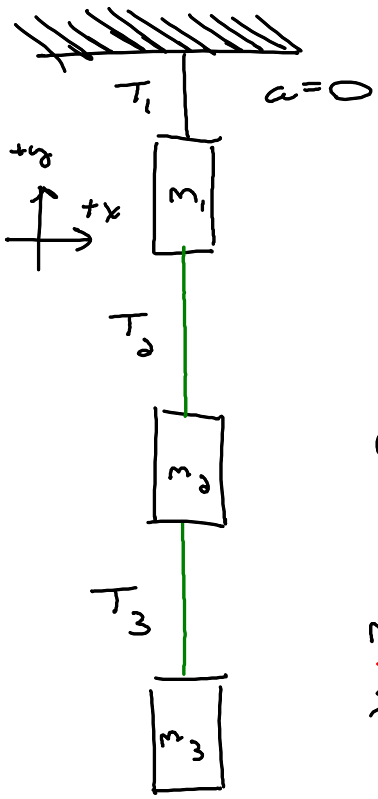
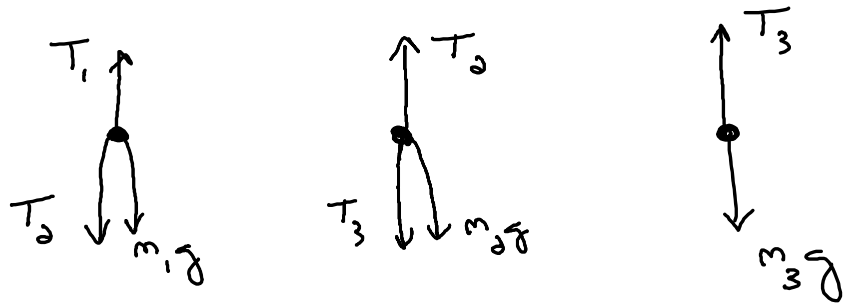
• Vertical Case A







m_1: $\Sigma F = T_1 - T_2 - m_1 g$

$$0 \leftarrow m_1 a = T_1 - T_2 - m_1 g$$

m_2: $\Sigma F = T_2 - T_3 - m_2 g$

$$0 \leftarrow m_2 a = T_2 - T_3 - m_2 g$$

m_3: $\Sigma F = T_3 - m_3 g$

$$0 \leftarrow m_3 a = T_3 - m_3 g$$

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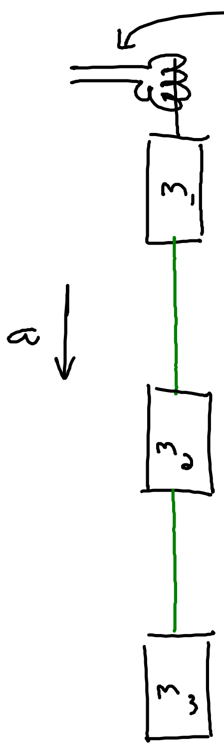
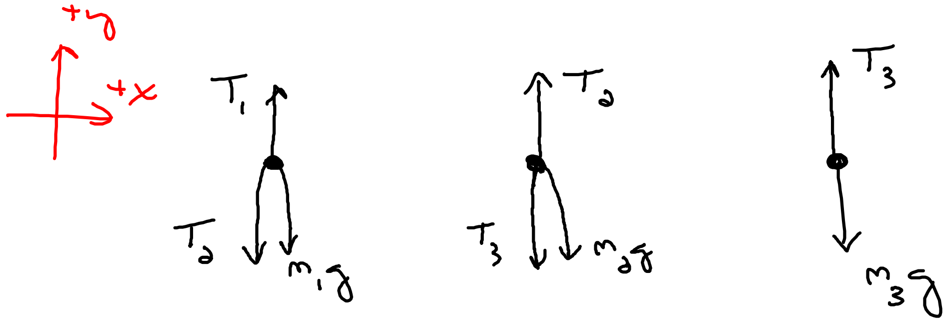
Vertical Case B

lowered with a downward acceleration of 0.2 g's.





$a = -1.96\ \mathrm{m/s^2}$

m_1: $\Sigma F = T_1 - T_2 - m_1 g$

$-m_1 a = T_1 - T_2 - m_1 g$

m_2: $\Sigma F = T_2 - T_3 - m_2 g$

$-m_2 a = T_2 - T_3 - m_2 g$

m_3: $\Sigma F = T_3 - m_3 g$

$-m_3 a = T_3 - m_3 g$

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assign hw

☆ Homework Assignment ☆

- Halliday (HRW) Chapter 5 Questions: 4
  Problems: 47, 51, 77

- Giancoli: Chapter 4 Questions: 7, 13
  Problems: 25, 88

- Scan #5 due Monday 12DEC11
- Related Rates project/poster due 21DEC11

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