College Physics I: 1511 Mechanics & Thermodynamics

Professor Jasper Halekas
Van Allen Lecture Room 1
MWF 8:30-9:20 Lecture

Announcements

- Friday's exam will have randomized seating
  - Pick up your exam (answer sheet inside) before 8:30 and find your seat
  - Sign and print your name on the cover sheet and fill out your name/ID on answer sheet, but don't open the exam until I give you the go-ahead
- Exam is closed-book
  - Calculators are allowed as long as they are not connected to the internet in any way
  - Bring a pencil!
- Bring your ID – it will be checked when you hand in the exam
  - Turn in both answer sheet and signed exam

Announcements II

- Exam is 15 multiple-choice questions
  - Questions are a mix of conceptual and mathematical
  - The intended mean on the exam is ~60%.
  - Don't worry if you can't solve every question.
  - Not every question is equal in difficulty. Be strategic in how you spend your time.
- Exam will cover:
  - Ch. 2-4: All Sections
  - Ch. 5: 5.1-5.3, 5.7 (not 5.4-5.6)
  - Ch. 6: 6.1-6.6 (not 6.7-6.9)

Equation Sheet

Trigonometry (*For right triangle with sides Adjacent, Opposite, and Hypoteneuse):*

Sin(θ) = O/H *Cos(θ) = A/H* *Tan(θ) = O/A* $H^2 = O^2 + A^2$ $A_{circle} = \pi r^2$

Sin(30°) = Cos(60°) = ½ *Sin(60°) = Cos(30°) =*$\sqrt{3}/2$ *~=0.866* *Sin(45°) = Cos(45°) =* $\sqrt{2}/2$ *~0.707*

Sin(0°) = Cos(90°) = 0 *Sin(90°) = Cos(0°) = 1*

Kinematics:

$\langle\vec{v}\rangle = \frac{\Delta\vec{r}}{\Delta t}$ $\langle\vec{a}\rangle = \frac{\Delta\vec{v}}{\Delta t}$ $\vec{r}(t) = \vec{r_0} + \vec{v_o}t + \frac{1}{2}\vec{a}t^2$ $v(t)^2 = v_o{}^2 + 2\vec{a}\cdot\Delta\vec{r}(t)$

Newton's Laws:

$\sum\vec{F} = m\vec{a}$ $\overrightarrow{F_{AB}} = -\overrightarrow{F_{BA}}$

Forces:

$F_G = mg$ (@ surface) ${f_s}^{MAX} = \mu_s F_N$ $f_k = \mu_k F_N$

$F_C = ma_c = \frac{mv^2}{r}$ $F_{spring} = -kx$

Work & Energy:

$KE_{trans} = \frac{1}{2}mv^2$ $\Delta KE = W_{net}$ $PE_G = mgh$ $PE_{spring} = \frac{1}{2}kx^2$

$E = KE + PE$ $\Delta E = W_{nc}$ $W = \vec{F}\cdot\Delta\vec{r} = |\vec{F}||\Delta\vec{r}|\cos\theta_{Fdr}$

Rotational Motion:

$\theta = s/r$ $a_c = \frac{v^2}{r}$

Basic Trigonometry

Trigonometry (*For right triangle with sides Adjacent, Opposite, and Hypoteneuse):*

$Sin(\theta) = O/H$ $Cos(\theta) = A/H$ $Tan(\theta) = O/A$ $H^2 = O^2 + A^2$ $A_{circle} = \pi r^2$

$Sin(30°) = Cos(60°) = ½$ $Sin(60°) = Cos(30°) = \sqrt{3}/2$ ~=0.866 $Sin(45°) = Cos(45°) = \sqrt{2}/2$ ~0.707

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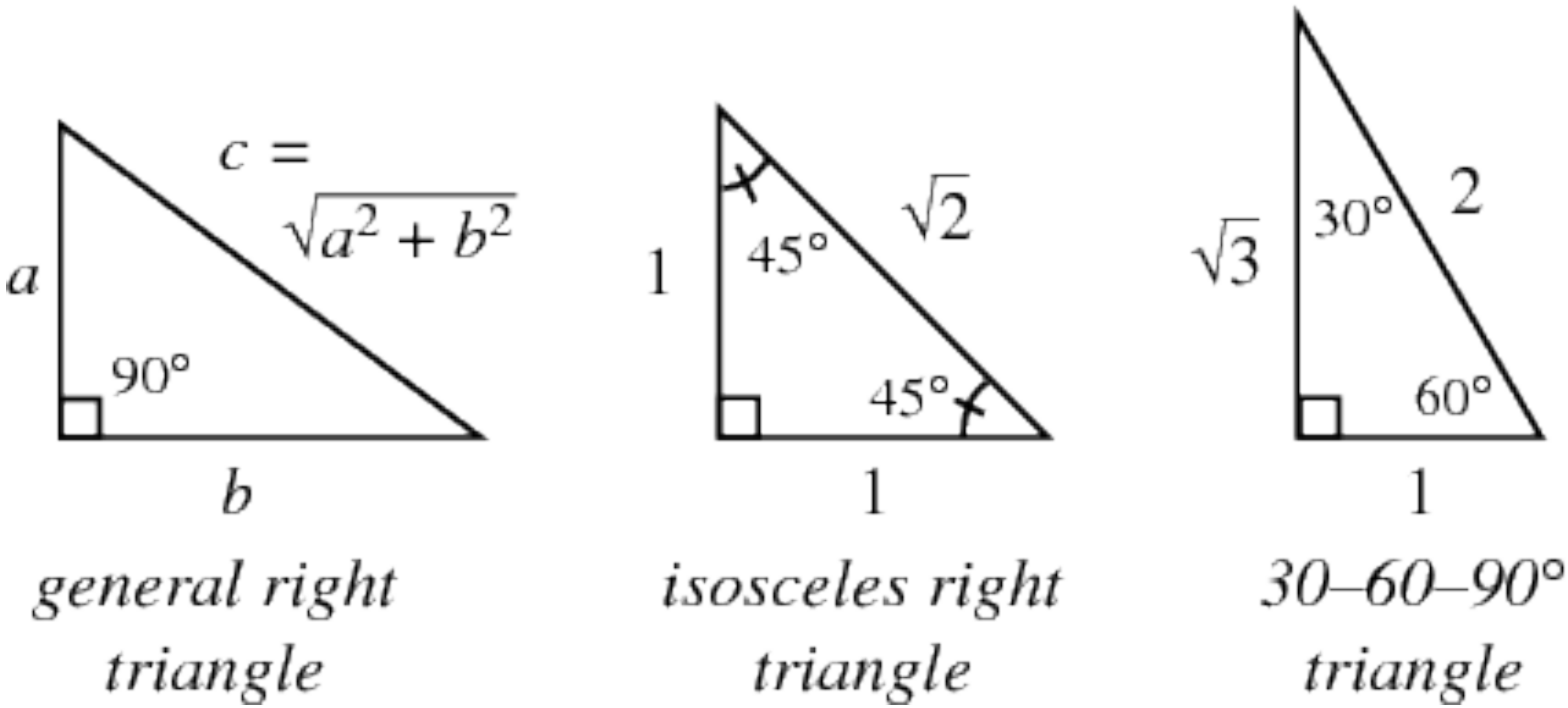

Kinematics

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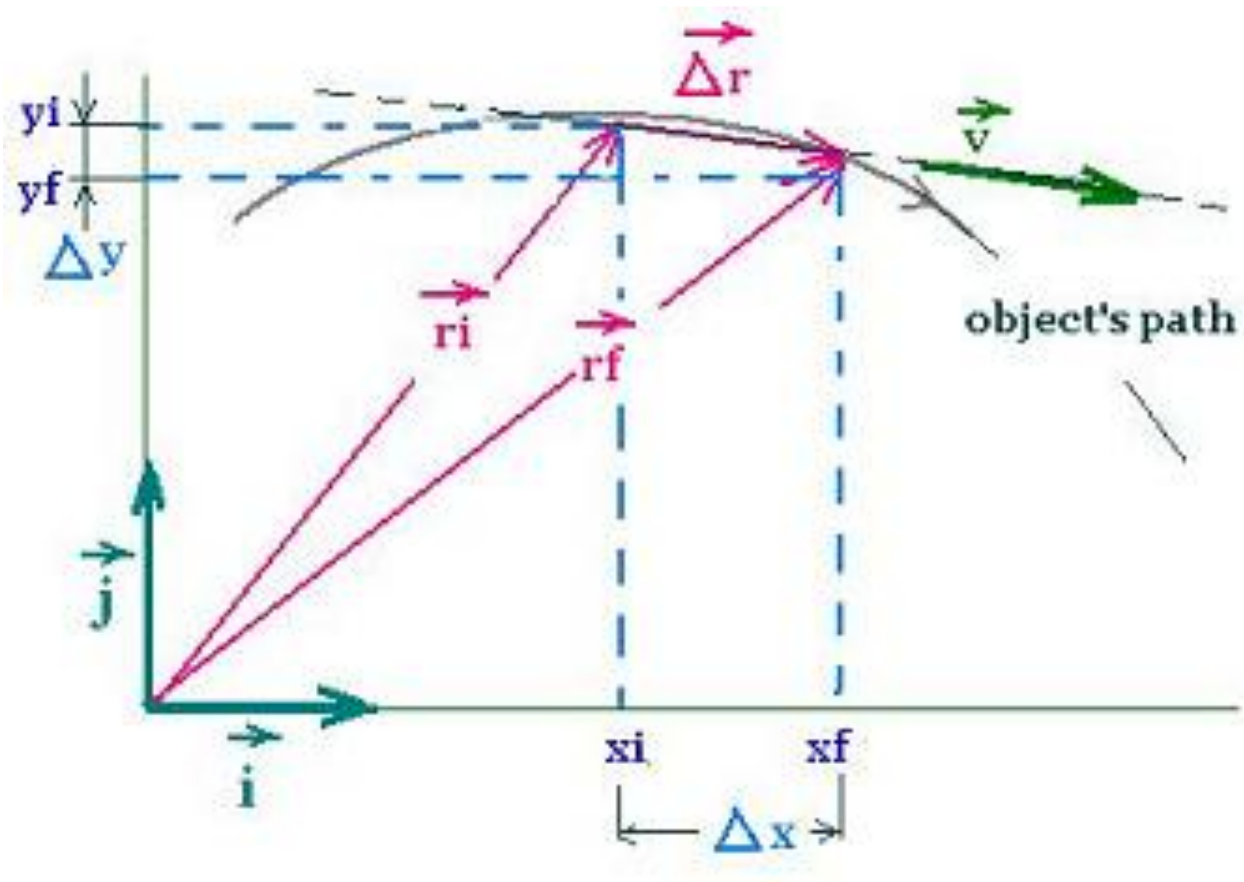


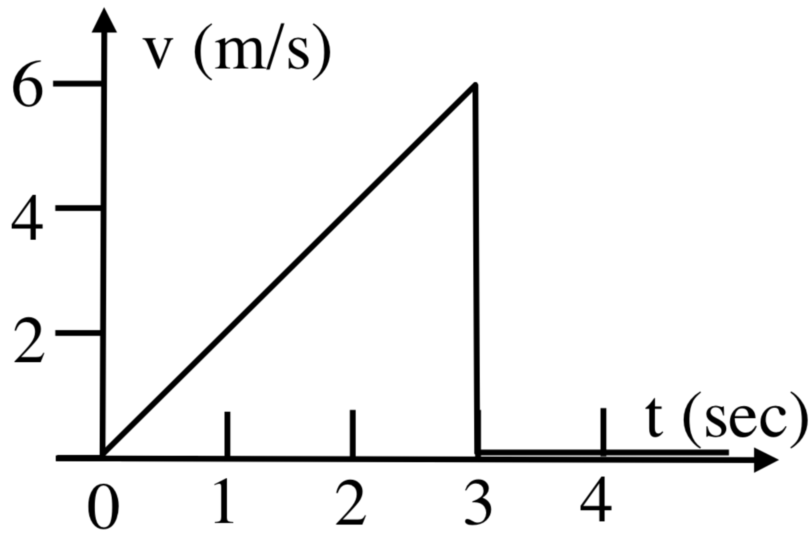
2-d Kinematics

Kinematic Equations

X	**Y**
I. $v_x = v_{0x} + a_x t$	I. $v_y = v_{0y} + a_y t$
II. $x = x_0 + v_{0x} t + \frac{a_x}{2} t^2$	II. $y = y_0 + v_{0y} t + \frac{a_y}{2} t^2$
III. $v_x{}^2 = v_{0x}^2 + 2a_x (x - x_0)$	III. $v_y{}^2 = v_{0y}^2 + 2a_y (y - y_0)$

Sample Question

A particle starts at the origin. Below is a graph of velocity vs. time.



What is the approximate position at t=3 sec?

A: 3 m B: 6 m

C: 9 m D: 18 m

E: None of these/not enough information.

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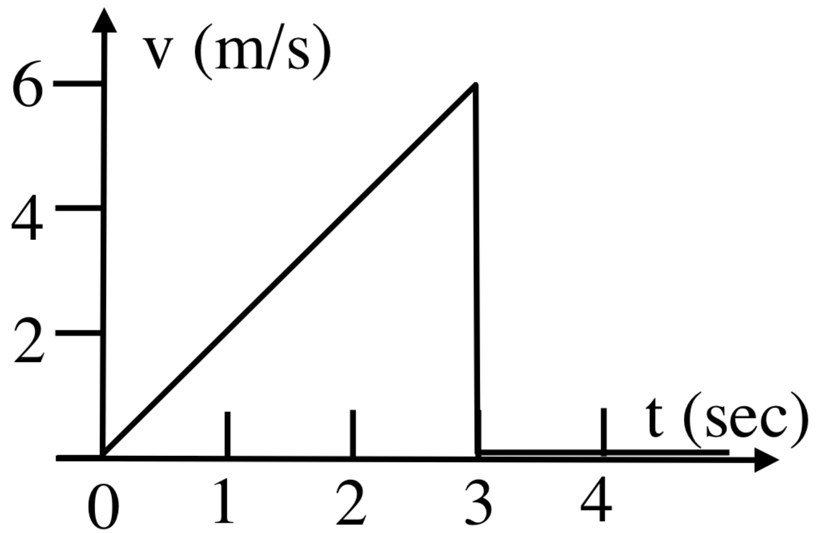

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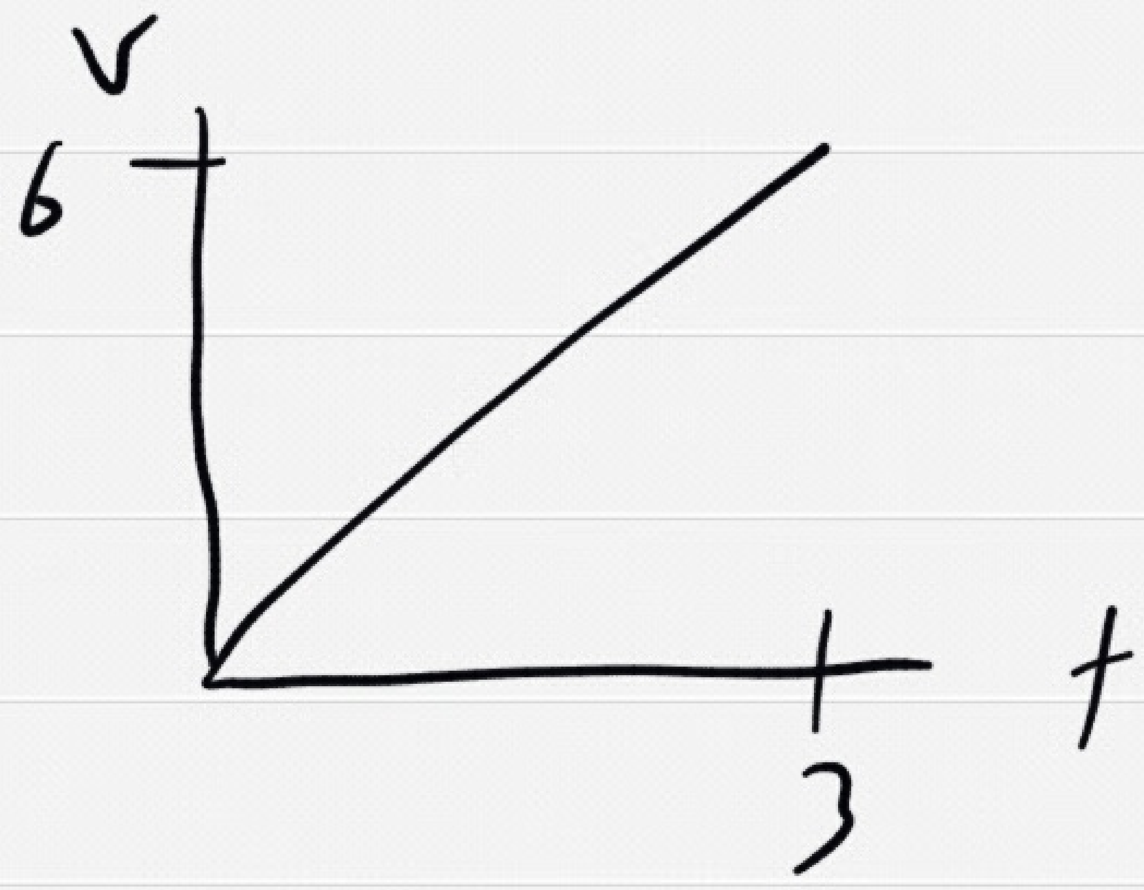

$$v = 2t$$
$$= at \Rightarrow a = 2$$

$$x = x_0 + v_0 t + \frac{1}{2} a t^2$$
$$= \frac{1}{2} a t^2$$
$$= \frac{1}{2} \cdot 2 \cdot 3^2$$
$$= \boxed{9\ m}$$

or, see

$$\langle v \rangle = 3\ m/s$$

$$\Delta x = \langle v \rangle t$$
$$= 3 \cdot 3$$
$$= 9\ m$$

Sample Question

- A rock is dropped from rest from a height *h* above the ground. It falls and hits the ground with a speed of 11 m/s. From what height should the rock be dropped so that its speed on hitting the ground is 22 m/s? Neglect air resistance.

A. 4.0*h*
B. 2.0*h*
C. 0.71*h*
D. 3.0*h*
E. 1.4*h*

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$$v^2 = v_0^2 + 2a\Delta x$$
$$= 2 \cdot -g \cdot -h \quad = 2gh$$

double v

$$\rightarrow \quad (2v)^2 = 4v^2$$
$$= 4(2gh)$$

$$\Rightarrow \quad h \rightarrow 4h$$

Sample Question

- A ferry can travel at a speed of 8 km/h in still water, relative to the dock. What is the speed of the ferry, as seen from the dock, if it moves perpendicular to a 6 km/h current that carries it downstream?

A. 14 km/h
B. 8 km/h
C. 28 km/h
D. 4 km/h
E. 10 km/h

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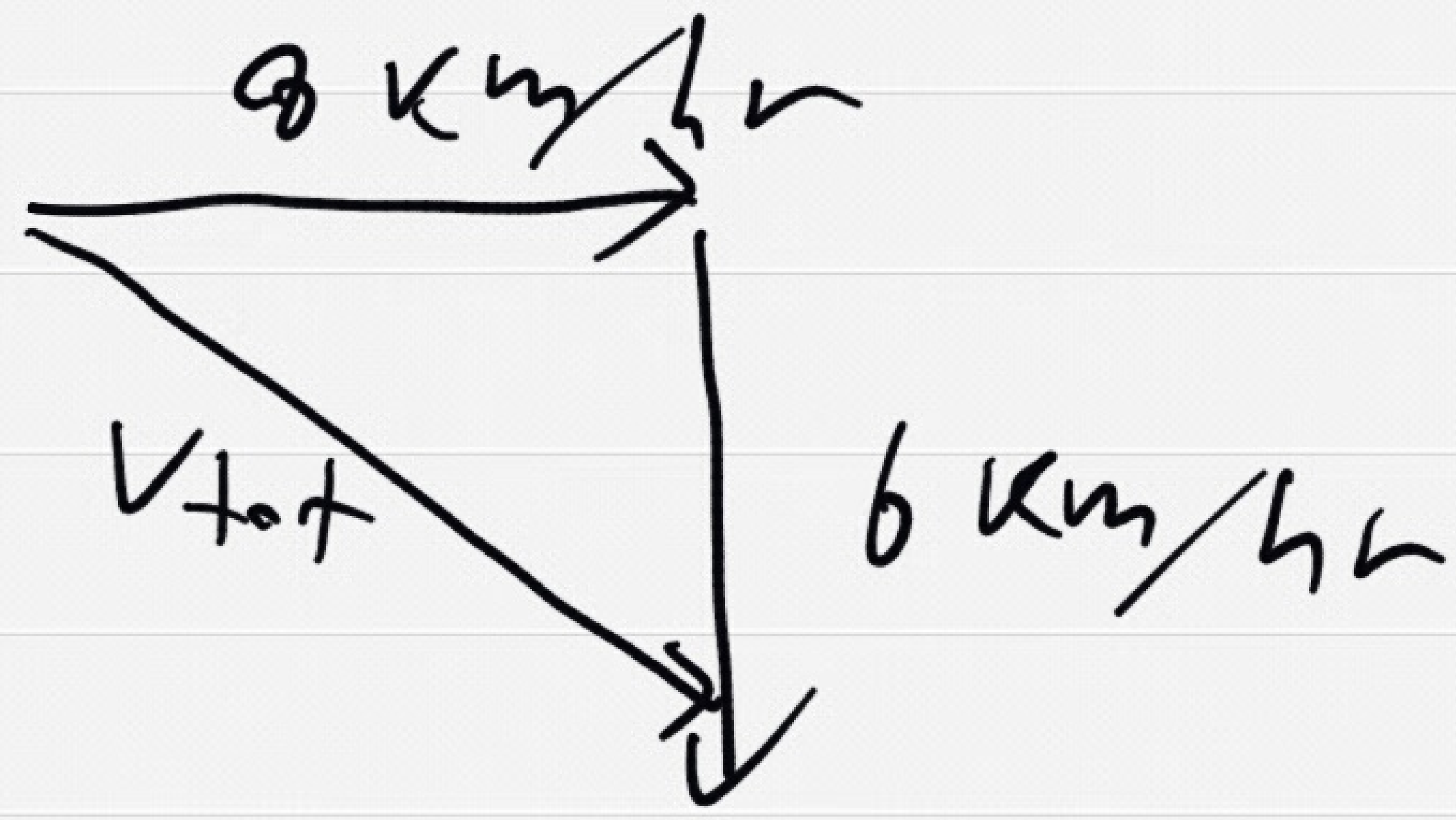


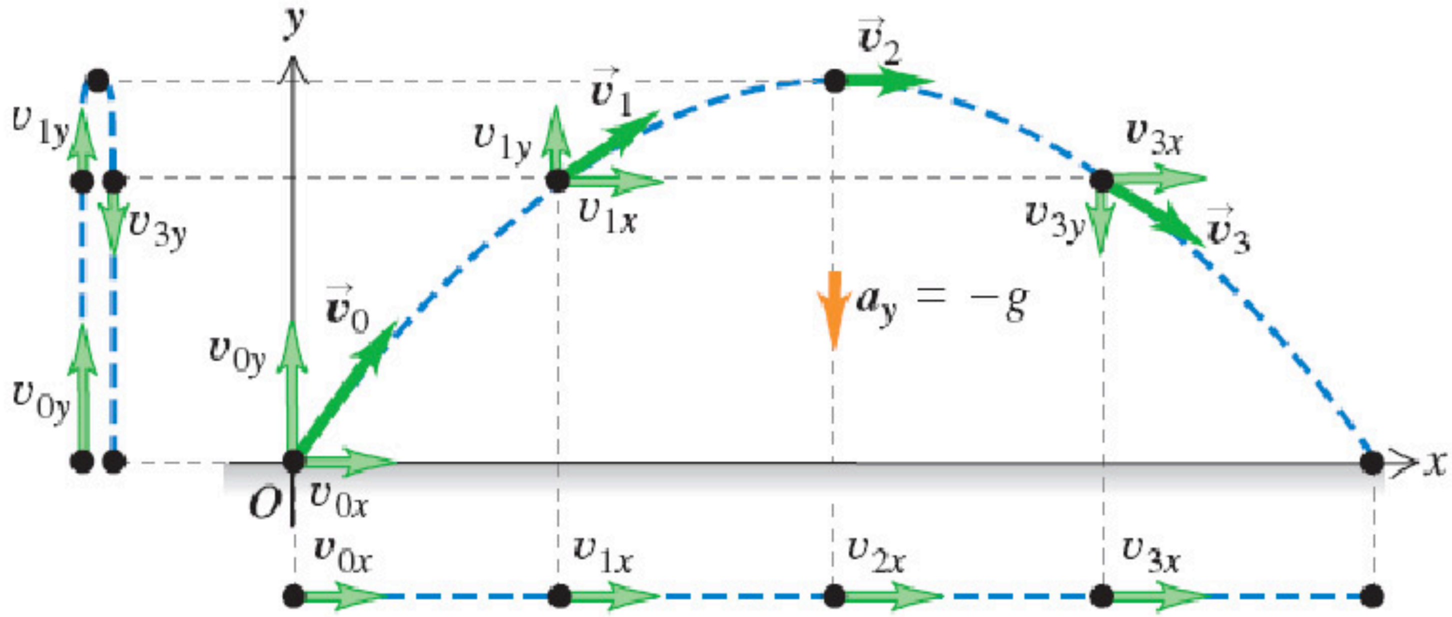
$$V_{tot} = \sqrt{8^2 + 6^2}$$

$$= \sqrt{64 + 36}$$

$$= \sqrt{100}$$

$$= 10 \text{ km/hr}$$

Projectile Motion



The vertical and horizontal components of a projectile's motion are independent.

$$x = (v_0 \cos\theta_0)t,$$

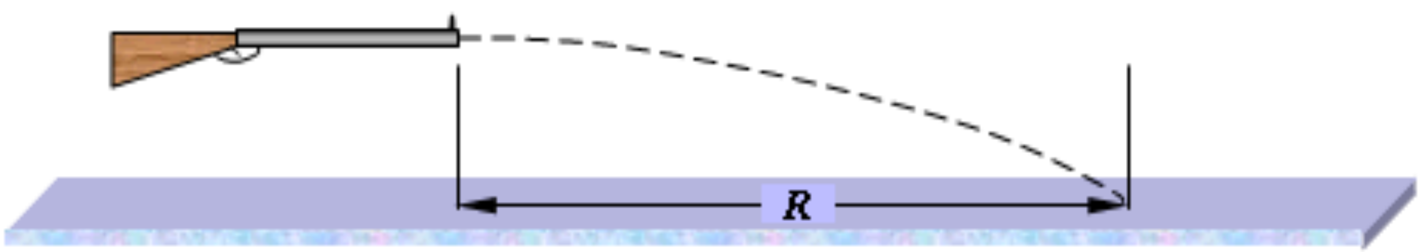
$$y = (v_0 \sin\theta_0)t - \frac{1}{2}gt^2,$$

$$v_x = v_0 \cos\theta_0,$$

$$v_y = v_0 \sin\theta_0 - gt.$$

Sample Question

- A spring-loaded gun is aimed horizontally and is used to launch identical balls with *different initial speeds.* The gun is at a fixed position above the floor. The balls are fired one at a time. If the speed of the second ball fired is twice the speed of the first ball fired, how is the horizontal range (denoted *R* in the figure) affected?



A. The range of the second ball will be twice as large as that of the first ball.
B. The range of the second ball is about 1.4 times larger than that of the first ball.
C. The range of the second ball will be smaller by a factor of 1.4.
D. The range for both balls will be the same.
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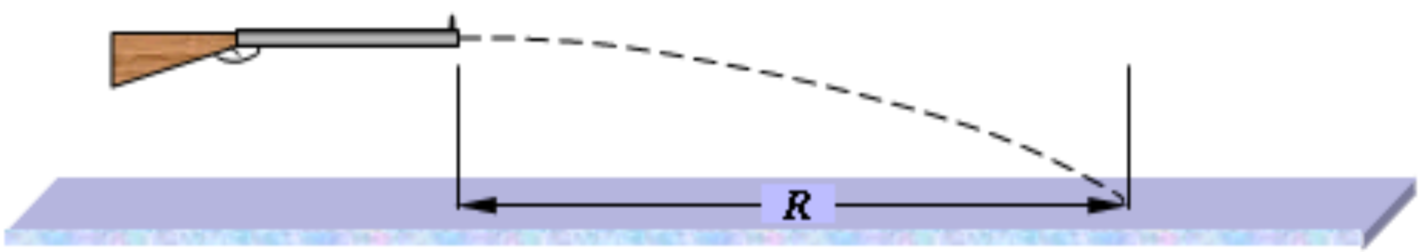

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$$y = y_0 + v_{y0} t + \frac{1}{2} a t^2$$

$$= y_0 - \frac{1}{2} g t^2$$

$$= 0$$

$$\Rightarrow \frac{1}{2} g t^2 = y_0$$

$$\Rightarrow t = \sqrt{2y_0 / g}$$

same regardless of v_x

$$\Delta x = v_{x0} t$$

double v_{x0} $\rightarrow$ double t

Newton's Laws

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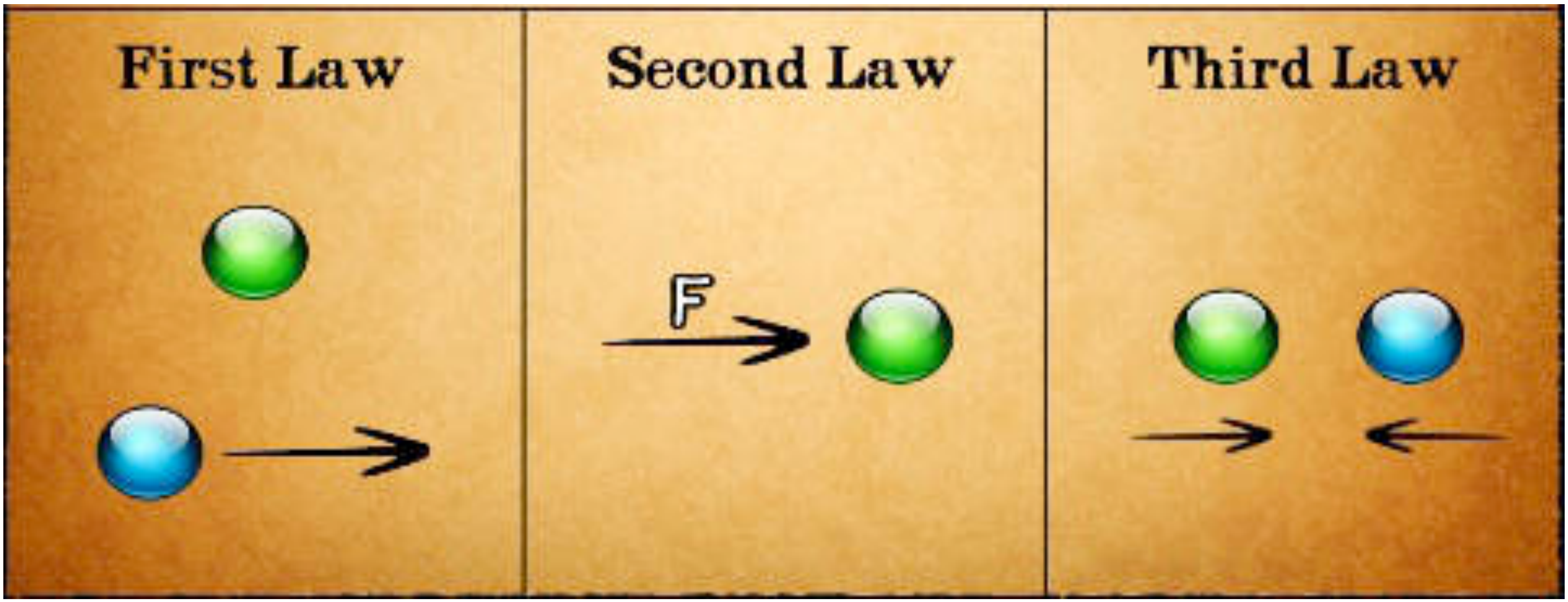
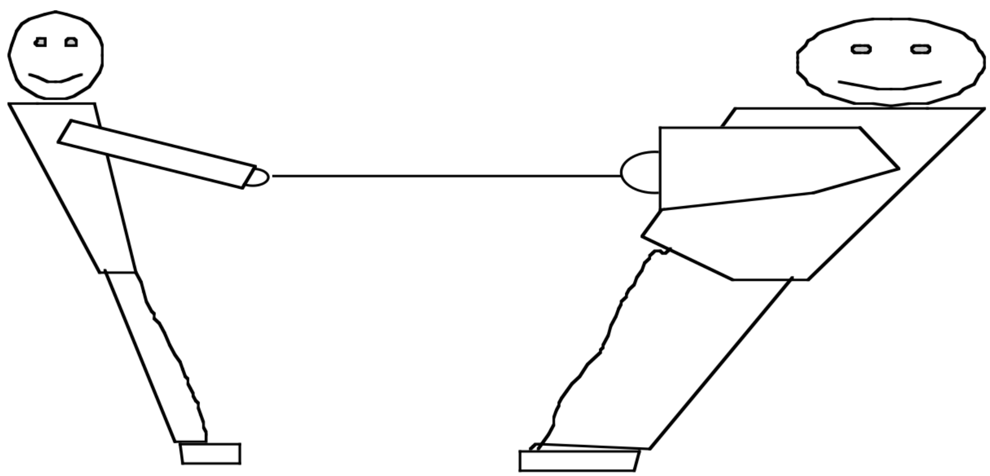
$\sum \overrightarrow{F} = m\vec{a}$ $\overrightarrow{F_{AB}} = -\overrightarrow{F_{BA}}$



Sample Question

Steve and a Sumo wrestler are having a tug-of-war. So far, no one is winning.



How does Fs (the magnitude of the force of friction on Steve's feet) compare with Fw (the force of friction on the feet of the sumo wrestler)

A: Fs > Fw B: Fs=Fw C: Fs < Fw.

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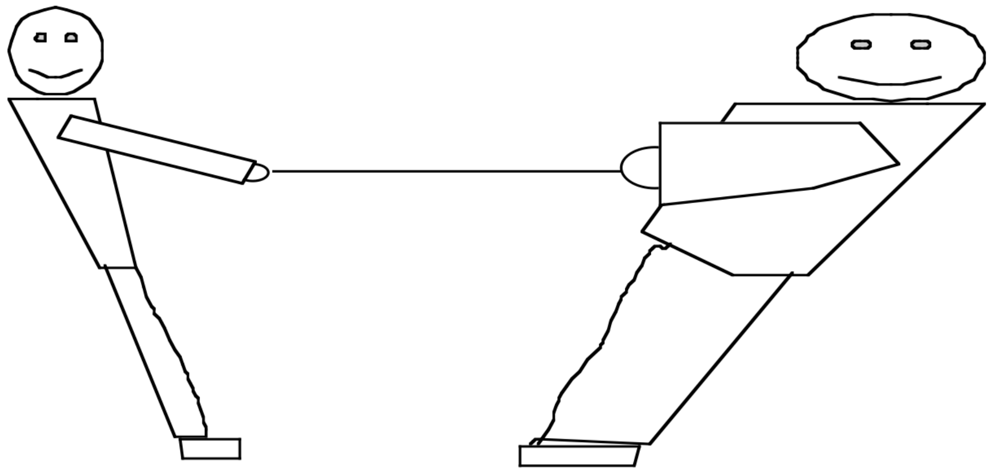

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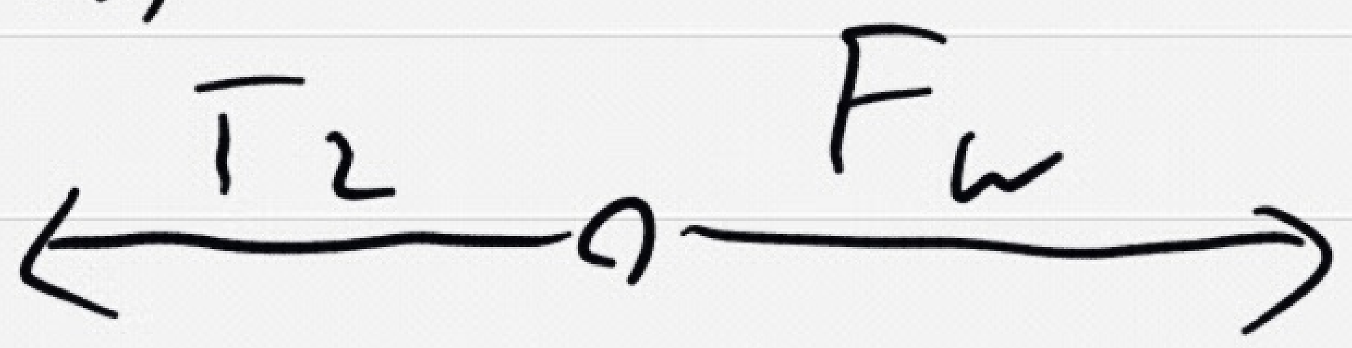
steve

Sumo



$|T_1| = |T_2|$

by Newton's 3rd

$|F_s| = |T_1|$ since not moving

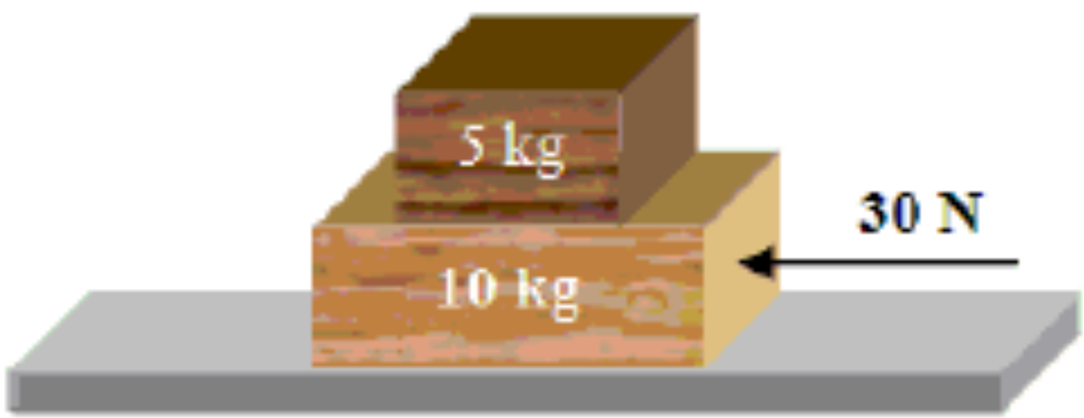
$|F_w| = |T_2|$

$\Rightarrow |F_w| = |F_s|$

Sample Question

- Two blocks rest on a horizontal *frictionless* surface as shown. The surface between the top and bottom blocks is roughened so that there is no slipping between the two blocks. A 30-N force is applied to the bottom block as suggested in the figure. What is the acceleration of the "two block" system?

A. 3 m/s^2
B. 15 m/s^2
C. 1 m/s^2
D. 2 m/s^2
E. 6 m/s^2



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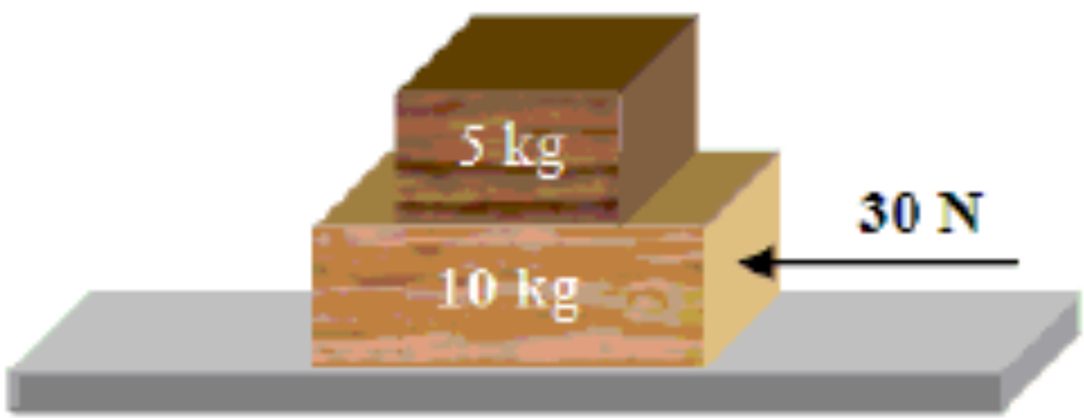
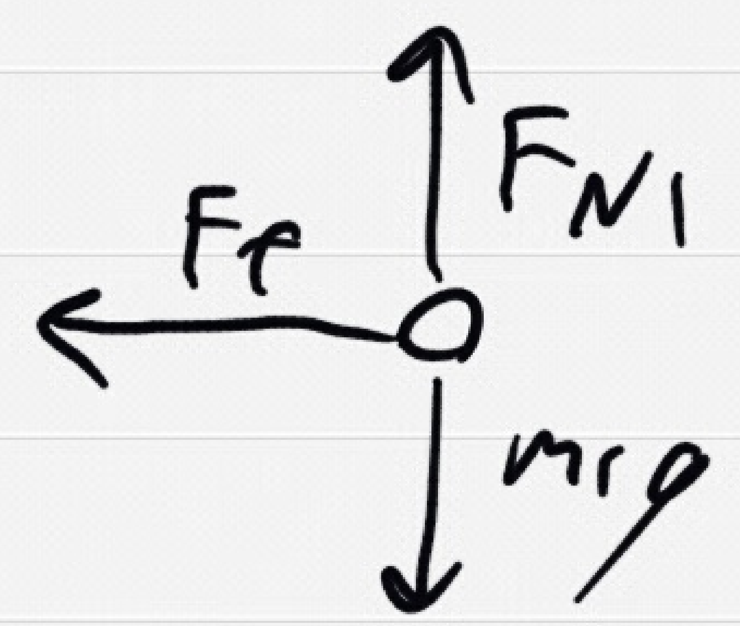


$$\Sigma \vec{F} = m\vec{a}$$

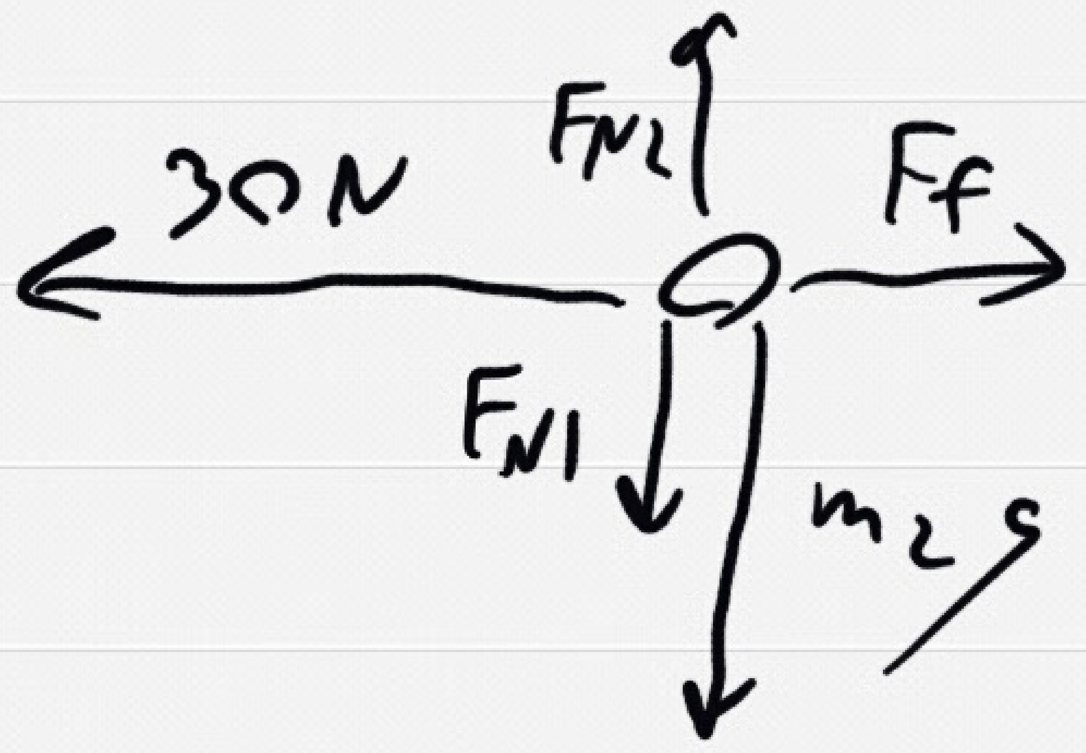
all mass accelerating together, so:

$$a = F/m$$
$$= 30/(10+5)$$
$$= 2\ m/s^2$$

Top Block:



Bottom



$$F_f = m_1 \cdot a$$
$$= 5 \cdot 2$$
$$= \boxed{10\ N}$$

$$F_{net} \text{ on } m_2 = 30N - F_f$$
$$= \boxed{20\ N}$$