PHY 113 A General Physics I
9-9:50 AM MWF Olin 101

Plan for Lecture 9:

Review of Chapters 1-5

1. Format of Wednesday's exam
2. Advice on how to prepare your equation sheet and your head for the exam
3. Review and example problems

No.	Lecture Date	Topic	Text Sections	Problem Assignments	Assignment Due Date
1	08/29/2012	Units & measurement	1.1-1.6	1.2,1.6,1.13,1.20	
2	08/31/2012	Motion in 1d -- constant velocity	2.1-2.3	2.1,2.8	09/07/2012
3	09/03/2012	Motion in 1d -- constant acceleration	2.4-2.8	2.13,2.16	09/07/2012
4	09/05/2012	Vectors	3.1-3.4	3.3,3.22	09/07/2012
5	09/07/2012	Motion in 2d	4.1-4.3	4.3,4.50	09/10/2012
6	09/10/2012	Circular motion	4.4-4.6	4.29,4.30	09/12/2012
7	09/12/2012	Newton's laws	5.1-5.6	5.1,5.13	09/14/2012
8	09/14/2012	Newton's laws applied	5.7-5.8	5.20,5.30,5.48	09/17/2012
	09/17/2012	Review	1-5		
	09/19/2012	Exam	1-5		
9	09/21/2012	More applications of Newton's laws	6.1-6.4		09/24/2012
10	09/24/2012	Work	7.1-7.4		09/26/2012

Format of Wednesday's exam

What to bring:

1. Clear, calm head
2. Equation sheet (turn in with exam)
3. Scientific calculator
4. Pencil or pen

(Note: labtops, cellphones, and other electronic equipment must be off or in sleep mode.)

Timing:

May begin as early as 8 AM; must end ≤ 9:50 AM

Probable exam format

- 4-5 problems similar to homework and class examples pertaining to Chapters 1-5 of your text.
- Full credit awarded on basis of analysis steps as well as final answer

iclicker exercise:

When do plan to start the exam on Wednesday, September 19th?

A. 8 AM
B. 8:30 AM
C. 9 AM

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What to include on equation sheet

Given information on exam	Suitable for equation sheet
Universal constants (such as $g=9.8 m/s^2$)	Trigonometric relations
Particular constants (such as μ_s, μ_k)	Simple derivative and integral relationships
Unit conversion factors if needed	General relationships of position, velocity, acceleration
	Particular formulas for trajectory motion
	Expression for centripetal acceleration
	Expressions for model friction forces

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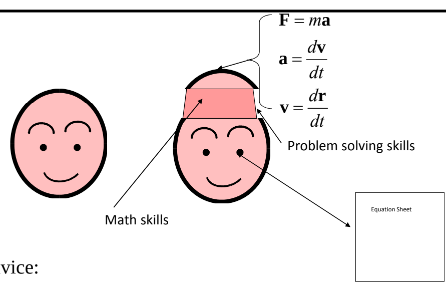

Advice:

1. Keep basic concepts and equations at the top of your head.
2. Practice problem solving and math skills
3. Develop an equation sheet that you can consult.

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Problem solving steps

1. Visualize problem – labeling variables
2. Determine which basic physical principle(s) apply
3. Write down the appropriate equations using the variables defined in step 1.
4. Check whether you have the correct amount of information to solve the problem (same number of knowns and unknowns).
5. Solve the equations.
6. Check whether your answer makes sense (units, order of magnitude, etc.).

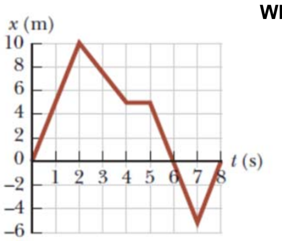
Review: position, velocity, and acceleration in one dimension

$$x = x(t)$$

$$v(t) = \frac{dx}{dt} \quad \Leftrightarrow \quad x(t) = \int_{t_0}^{t} v(t')dt'$$

$$a(t) = \frac{dv}{dt} \quad \Leftrightarrow \quad v(t) = \int_{t_0}^{t} a(t')dt'$$

Graphical representation *x(t)*



What is the velocity at *t=1s?*

What is the velocity at $t = 1s$?

$$v(t) = \frac{dx}{dt}$$

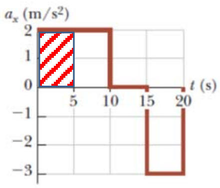
From tangent line:

$$v(1s) = \frac{x(2s) - x(0s)}{2s - 0s}$$

$$= \frac{10m - 0m}{2s - 0s} = 5m/s$$

Graphical representation of *a(t)*

What is the velocity at *t=5s?*



What is the velocity at $t = 5s$?

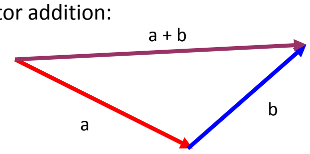
$$a(t) = \frac{dv}{dt} \quad \Leftrightarrow \quad v(t) = \int_{t_0}^{t} a(t')dt'$$

From area under curve:

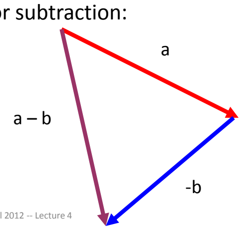
$$v(5s) = 2m/s^2 \cdot 5s = 10m/s$$

Abstract notion of vectors:

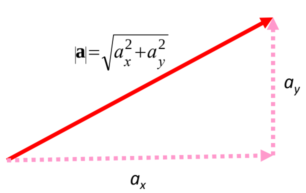
Vector addition:



Vector subtraction:



Vector components: $\mathbf{a} = a_x\hat{\mathbf{x}} + a_y\hat{\mathbf{y}} = a_x\hat{\mathbf{i}} + a_y\hat{\mathbf{j}}$



For $\mathbf{a} = a_x\hat{\mathbf{x}} + a_y\hat{\mathbf{y}}$ and $\mathbf{b} = b_x\hat{\mathbf{x}} + b_y\hat{\mathbf{y}}$

$$\mathbf{a} + \mathbf{b} = (a_x + b_x)\hat{\mathbf{x}} + (a_y + b_y)\hat{\mathbf{y}}$$

Example of vector addition:

Vectors relevant to motion in two dimenstions

Displacement: **r**(t) = x(t) **i** + y(t) **j**

Velocity: **v**(t) = $v_x(t)$ **i** + $v_y(t)$ **j** $\quad \mathbf{v}_x = \frac{dx}{dt} \quad \mathbf{v}_y = \frac{dy}{dt}$

Acceleration: **a**(t) = $a_x(t)$ **i** + $a_y(t)$ **j** $\quad \mathbf{a}_x = \frac{dv_x}{dt} \quad \mathbf{a}_y = \frac{dv_y}{dt}$

Projectile motion (near earth's surface)

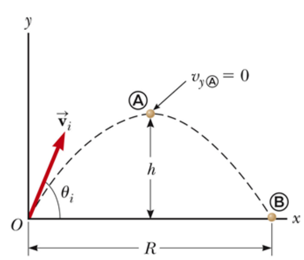
$$\mathbf{r}(t) = \mathbf{r}_i + \mathbf{v}_i t - \tfrac{1}{2} g t^2 \hat{\mathbf{j}} \qquad \mathbf{v}(t) = \frac{d\mathbf{r}}{dt} = \mathbf{v}_i - g t \hat{\mathbf{j}}$$

$$\mathbf{a}(t) = \frac{d\mathbf{v}}{dt} = -g\hat{\mathbf{j}}$$

$$\mathbf{v}_i = v_{xi}\hat{\mathbf{i}} + v_{yi}\hat{\mathbf{j}}$$

$$v_{xi} = |\mathbf{v}_i| \cos\theta_i$$

$$v_{yi} = |\mathbf{v}_i| \sin\theta_i$$



Projectile motion (near earth's surface)

Trajectory equation in component form:

$$x(t) = x_i + v_{xi}t = x_i + v_i \cos\theta_i t$$

$$y(t) = y_i + v_{yi}t - \tfrac{1}{2}gt^2 = y_i + v_i \sin\theta_i t - \tfrac{1}{2}gt^2$$

$$v_x(t) = v_{xi} = v_i \cos\theta_i$$

$$v_y(t) = v_{yi} - gt = v_i \sin\theta_i - gt$$

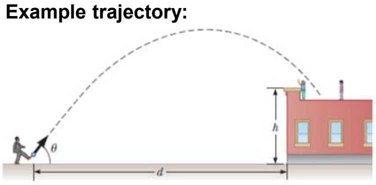
Trajectory path *y(x)*; eliminating *t* from the equations:

$$t = \frac{x - x_i}{v_i \cos\theta_i} \quad y(x) = y_i + v_i \sin\theta_i \frac{x - x_i}{v_i \cos\theta_i} - \tfrac{1}{2} g \left(\frac{x - x_i}{v_i \cos\theta_i} \right)^2$$

$$y(x) = y_i + \tan\theta_i (x - x_i) - \tfrac{1}{2} g \left(\frac{x - x_i}{v_i \cos\theta_i} \right)^2$$

Example trajectory:

h=7.1m
θ_i*=53*^{o}
d=24m=x(2.2s)



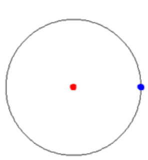
What is the initial velocity v_i?

$$x(t) = x_i + v_i \cos\theta_i t$$

$$x(2.2m) - x_i = d = 24m = v_i \cos 53^o \cdot 2.2s$$

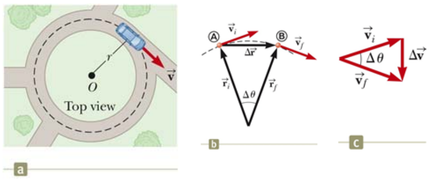
$$v_i = \frac{24m}{\cos 53^o \cdot 2.2s} = 18.13 m/s$$

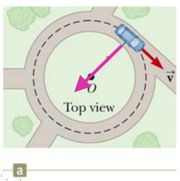
Uniform circular motion – another example of motion in two-dimensions



animation from
http://mathworld.wolfram.com/UniformCircularMotion.html

Uniform circular motion – continued

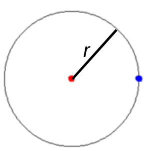




If $v_i = v_f \equiv v$, then the acceleration in the radial direction and the centripetal acceleration is :

$$\mathbf{a}_c = -\frac{v^2}{r}\hat{\mathbf{r}}$$

Uniform circular motion – continued



$$\mathbf{a}_c = -\frac{v^2}{r}\hat{\mathbf{r}}$$

$$\mathbf{a}_c = -\left(\frac{2\pi}{T}\right)^2 r\hat{\mathbf{r}}$$

$$\mathbf{a}_c = -(2\pi f)^2 r\hat{\mathbf{r}}$$

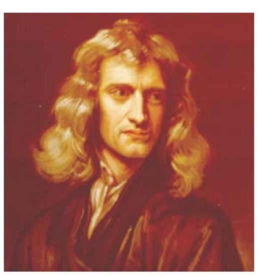
In terms of time period *T* for one cycle:

$$v = \frac{2\pi r}{T}$$

In terms of the frequency *f* of complete cycles:

$$f = \frac{1}{T}; \qquad v = 2\pi f r$$

Isaac Newton, English physicist and mathematician (1642—1727)



1. **In the absence of a net force, an object remains at constant velocity or at rest.**
2. **In the presence of a net force F, the motion of an object of mass m is described by the form F=ma.**
3. **F_{12} =– F_{21}.**

http://www.newton.ac.uk/newton.html

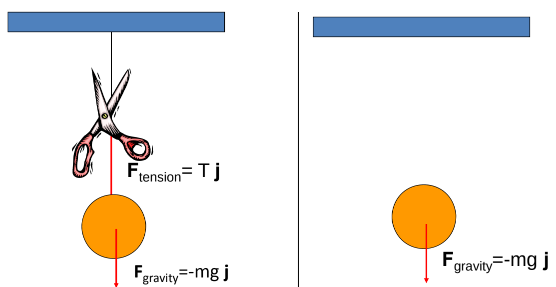
Newton's second law

F = m **a**

Types of forces:

Fundamental	Approximate	Empirical
Gravitational	F=-mg **j**	Friction
Electrical		Support
Magnetic		Elastic
Elementary particles		

Examples



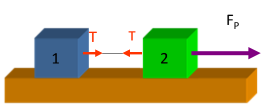
F=**F**$_{net}$=**F**$_{tension}$+**F**$_{gravity}$=(T-mg) **j** **=0**

F=**F**$_{net}$=**F**$_{gravity}$=(-mg) **j = m a**

→ **a=-gj**

Free body diagrams:

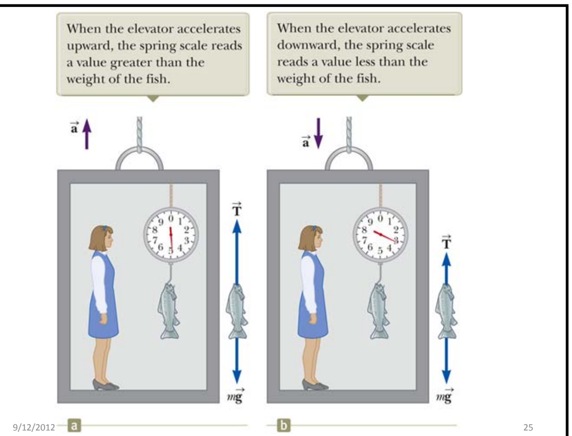
Consider m_1 and m_2 moving on a frictionless surface; connected with rope having tension T and pulled with force F_P. If m_1, m_2, and F_P are given, find T



$$T = m_1 a \qquad F_P - T = m_2 a$$

$$F_P = T + m_2 a = m_1 a + m_2 a$$

$$T = F_P \frac{m_1}{m_1 + m_2} \Leftarrow a = \frac{F_P}{m_1 + m_2}$$



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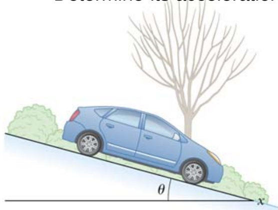
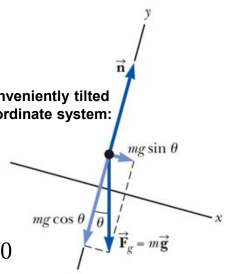
Example: 2-dimensional forces

A car of mass m is on an icy (frictionless) driveway, inclined at an angle t as shown. Determine its acceleration.





Along y: $n - mg\cos\theta = 0$

Along x: $mg\sin\theta = ma_x$

$a_x = g\sin\theta$

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Friction forces

The term "friction" is used to describe the category of forces that *oppose* motion. One example is surface friction which acts on two touching solid objects. Another example is air friction. There are several reasonable models to quantify these phenomena.

Surface friction: $f = \begin{cases} -F_{applied} \\ \pm \mu N \end{cases}$ — Normal force between surfaces; Material-dependent coefficient

Air friction: $D = \begin{cases} -Kv & \text{at low speed} \\ -K'v^2 & \text{at high speed} \end{cases}$

K and *K'* are materials and shape dependent constants

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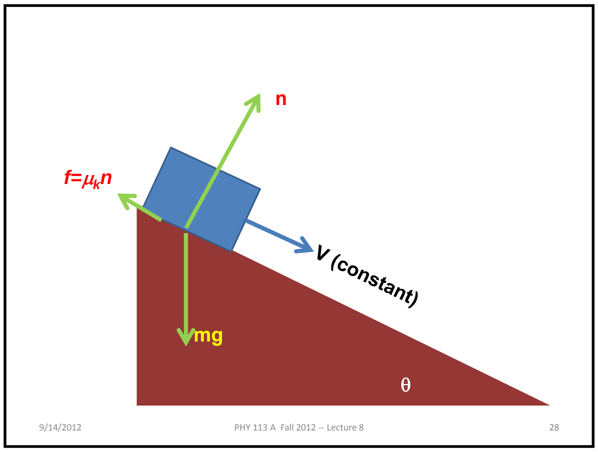
n
f=μ_k n
V (constant)
mg
θ
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