Syllabus

Tuesday, September 30, 2008
3:33 PM

Syllabus Physics 6A, Fall 2008

Instructor: Robijn Bruinsma
Knudsen 3-120, bruinsma@physics.ucla.edu, 5-8539
Office Hour: TBA

Teaching Assistant: TBA

Class:
MWF, 11:00AM - 11:50P
Physics and Astronomy Building 1425

Class Information:
http://ccle.ucla.edu/course/view/08F-PHYSICS6A-3
Questions concerning the class or homework can be posted on the discussion board of this site.

Required Texts:

Serway and Jewett,
Principles of Physics (4th edition) (3-vol Split)
With Webassign/smrt CENGAGE Bundle, 4, 08

Huffman,
Physics 6A Lab Workbook (Fall 2008) HAYDEN MCNEIL
Spiral

Optional Text:

MCAT Package

Exam Schedule:

First Midterm – Monday, October 20, in class

Second Midterm – Wednesday, November 12, in class

Final Exam – Tuesday, December 9, 8-11 pm

The grade in the course is based on performance on the exams, along with the scores earned on the problem sets and lab reports. Here is how the grade is computed, in terms of the weights attached to the various components of each student's performance:

Each midterm – 20%

Final exam – 35%

Problem set scores – 10%

Lab reports – 15%

More on exams:

The dates of the exams are fixed at the beginning of the course, and are not subject to alteration. You will inevitably face complications associated with exam schedules and find that you have more than one midterm, or more than one final, in one day. Alternatively, a long project in one course may be due the same day as an important exam in another. I understand, but I cannot change the date of an exam. Furthermore, there are no makeup exams, and students will not be allowed to take an exam earlier or later than the rest of the class.

Important: Problem Sets

Although problems sets account for only 10% of your final grade, they are very important. You can expect that the midterms and final will contain problems based on homework problems. If you can do the homework sets, you ought to be well-prepared for the exams. I encourage collaboration between students when working on problem sets (except during exams). It is helpful to talk over specific problems with others to sharpen your understanding. However, *copying* someone else's solutions is pointless.

Problem Set Schedule:

Problem Sets will be posted on the Webassign website
https://www.webassign.net/login.html
on Mondays. Check that you indeed have access. The problem sets will be discussed in your discussion section. The due date is the following Monday with a 12:00 pm deadline. The solutions and your homework grade become available at that time. You cannot submit homework after the deadline. There will be review sessions before each midterm, and before the final exam. The sessions will be scheduled in consultation with the students in the class.

Preliminary outline of the topics covered in this course.

This is not an exhaustive or entirely organized listing of topics. It is, rather, intended to give you a flavor of the course.

Week 1: Introduction and Vectors, SJ Ch.1

Week 2: Motion in One Dimension, SJ Ch.2

Week 3: Motion in Two Dimensions, SJ Ch.3

Week 4: The Laws of Motion, SJ Ch.4

Week 5: The Laws of Motion II, SJ Ch.5

Week 6: Energy, SJ Ch.6

Week 7: Energy II, SJ Ch.7

Week 8: Momentum, SJ Ch. 8

Week 9: Rotational Motion, SJ Ch.10

Week 10: Gravity and Planetary Orbits, SJ Ch.11.1-11.4

Discussion Week 1

Thursday, September 25, 2008
3:45 PM

1. Dimensional Analysis

<u>units</u>

$$\underset{m/s}{v_f} = \underset{m/s}{v_i} + \underset{m/s^2}{a}\,\underset{s}{t}$$

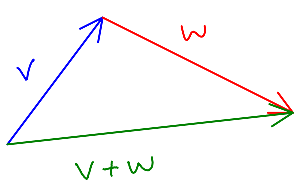
Example:

$$x = \frac{1}{2} g^n t^2$$

What is n?
[x] = meters
[t] = seconds
[g] = m/s^2

$$m = \frac{s^2 m^n}{s^{2n}} \Rightarrow n = 1$$

2. Vectors



$v = (x_1, y_1)$

$y = (x_2, y_2)$

$v + w = (x_1 + x_2, y_1 + y_2)$

Examples of vectors: position, velocity, acceleration

3. Derivatives

Rate of change

rate of change $(\vec{x}(t))$ = velocity

Lecture 09/25

Friday, September 26, 2008
11:04 AM

Office hours
- Th 5:30-6:30
- W 5-6

Tutoring Center
- Knudson 2240 (schedule on door)

Midterm I: Oct 20, Monday
Midterm II: Nov 12, Wed
Final: Dec 9, Tue, 8-11

Grade:
- Midterms 20% each
- Final 25%
- Homework 10%
- Lab 15%

Website:
- Webassign

- What is physics?
  - Description of material world
  - Establish relationships between quantities
  - Determine natural laws

- Measure quantities

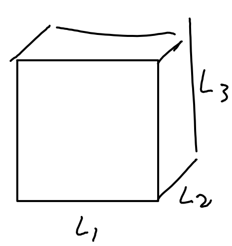
- Length: how far?
  - meters
- Time: how long
  - Seconds
- Mass: how hard is it to set object into motion
  - Measured in kg

Example:

Volume V

$$V = L_1 \times L_2 \times L_3$$

units m^3



Density

$$\rho = \frac{m}{V}$$

Speed

Speed

$$S = \frac{L_2 - L_1}{T_2 - T_1} \qquad \text{units } m/sec \qquad [S] = \frac{[L]}{[T]}$$

$$x(t) = \frac{1}{2} at^2$$
$$[L] = [a][T]^2$$

$$[a] = \frac{[L]}{[T]^2} \qquad \boxed{[DIM] = [DIM]}$$

$$T(\text{universe}) \cong 5 \times 10^{17} \text{ sec}$$
$$T(\text{nuclear collision}) \simeq 1 \times 10^{-22} \text{ sec}$$

$$x^n \times x^m = x^{n+m}$$
$$x^n / x^m = x^{n-m}$$
$$(x^n)^m = x^{nm}$$

do not put on calculator for large or small values

$$\left(\frac{5}{1}\right) \times 10^{17-(-22)} = 5.0 \times 10^{39}$$

Significant Figures:

- Two significant figures for this class
- Number of significant figures in multiplication or division is equal to the number of significant figures with the smallest number of significant figures

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Lecture 09/29

Monday, September 29, 2008
10:54 AM

Lecture 0929
Audio recording started: 10:57 AM Monday, September 29, 2008

Mechanics:

	Length	Mass	Time
	[L]	[M]	[T]
SI	meter	kg	sec

Dimensions: how a quantity is expressed in terms of L, M, T

$$[V] = \frac{[L]}{[T]}$$

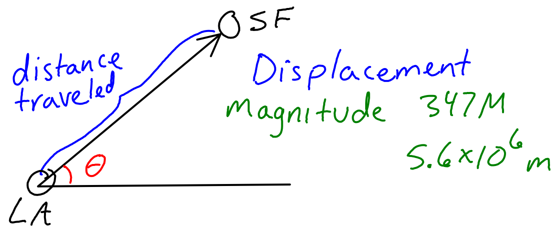
Scalars:

Temperature
atoms
Time
Speed

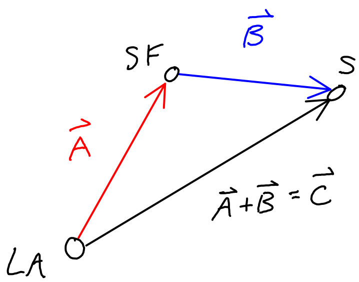
Vectors:

Displacement $\vec{R}$ or $\vec{x}$
Velocity $\vec{V}$ or $\vec{v}$
Acceleration $\vec{a}$
Force $\vec{F}$ or $\vec{f}$

cannot add scalars and vectors



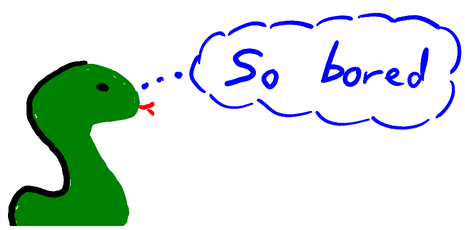
Vector Arithmetic:

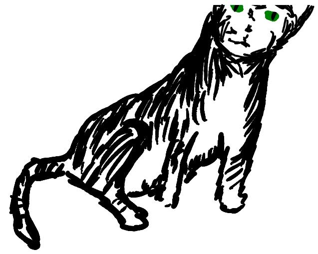


Commutative: $\vec{A}+\vec{B}=\vec{B}+\vec{A}$

Additive: $\vec{A}+(\vec{B}+\vec{C})=\vec{A}+(\vec{B}+\vec{C})$

Example Serway 1:38





polar coordinates (r, θ)

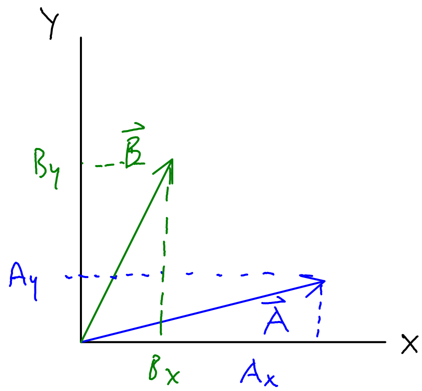
$x = r\cos\theta$

$y = r\sin\theta$

Cartesian (x, y)

$r = \sqrt{x^2 + y^2}$

$\tan\theta = \dfrac{y}{x}$



$$\vec{A} \pm \vec{B} = (A_x \pm B_x,\ A_y \pm B_y)$$

Homework #1 Questions

Tuesday, September 30, 2008
11:50 PM

WebAssign

Homework Ch.1 (Homework)

HEATHER CATHERINE GRAEHL
Physics 6A, Fall 2008
Instructor: Robijn Bruinsma

Current Score: 0 out of 43

Due: Monday, October 6, 2008 11:59 PM PDT

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1. [SerPOP4 1.P.009.] --/3 points

Assume it takes 5.00 minutes to fill a 15.0 gal gasoline tank. (1 U.S. gal = 231 in.^{3})

(a) Calculate the rate at which the tank is filled in gallons per second.

0.050 gal/s $\frac{15.0\,gal}{5.00\,min} \times \frac{1\,min}{60\,sec} = 0.050\,gal/s$

(b) Calculate the rate at which the tank is filled in cubic meters per second.

1.89×10^{-4} m^3/s $\frac{0.050\,gal}{sec} \times \frac{231\,in^3}{1\,gal} \times \frac{2.83 \times 10^{-2}\,m^3}{1.728\,in^3} = 1.89 \times 10^{-4}\,m^3/s$

$\frac{1\,m^3}{t} = \frac{1.89 \times 10^{-4}\,m^3}{s}$

(c) Determine the time interval, in hours, required to fill a 1 m^3 volume at the same rate.

1.47 h $\cancel{\frac{1.89 \times 10^{-4}\,m^3}{1\,s} \times \frac{60\,s}{1\,hr} = 0.0113562\ldots m^3/hr}$ ~~0.01134 m³/hr~~

$1\,m^3 \times \frac{1\,s}{1.89 \times 10^{-4}\,m^3} \times \frac{1\,min}{60\,s} \times \frac{1\,hr}{60\,min} = 1.47\,hr$

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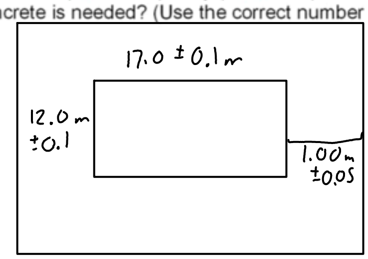
2. [SerPOP4 1.P.027.] --/2 points

A sidewalk is to be constructed around a swimming pool that measures (12.0 ± 0.1) m by (17.0 ± 0.1) m. If the sidewalk is to measure (1.00 ± 0.05) m wide by (7.0 ± 0.3) cm thick, what volume of concrete is needed? (Use the correct number of significant figures in your answer.)

$7.0 \times 10^{-2}\,m \pm 0.3 \times 10^{-2}$

4.3 m^3



201.11 269.31
206.91 262.71

61.6 68.2
4.312 4.774
Δ.5

What is the approximate uncertainty of this volume?

%

$(19 \times 14) - (17 \times 12)$

$62\,m^3$

$7\,cm \times \frac{1\,m}{100\,cm} \times 62$

3. [SerPOP4 1.P.034.] --/5 points

Two points in the xy plane have cartesian coordinates (2.00, -5.00) m and (-4.00, 4.00) m.

(a) Determine the distance between these points.

$\sqrt{117}$ m $\quad \sqrt{36+81}$

(b) Determine their polar coordinates.

(2.00, -5.00)

$r =$ $\sqrt{29}$ m

$\theta =$ -68.2 ° (counterclockwise from the + x axis is positive)

$x = r\cos\theta$

$y = r\sin\theta$

$r = \sqrt{x^2+y^2}$

$r = \sqrt{4+25} = \sqrt{29}$

$\tan\theta = -\frac{5}{2}$

$\tan^{-1}\left(-\frac{5}{2}\right) = \theta$

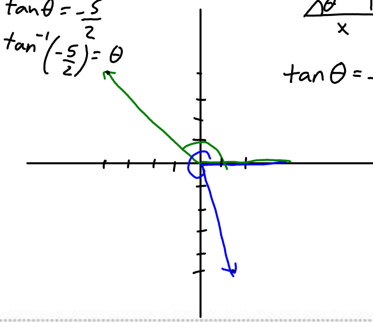
(-4.00, 4.00)

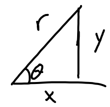
$r =$ $4\sqrt{2}$ m

$\theta =$ 135 ° (counterclockwise from the + x axis is positive)

$r = \sqrt{16+16} = \sqrt{32} = 4\sqrt{2}$

$\tan\theta = (-1)$





$\tan\theta = \frac{y}{x}$

4. [SerPOP4 1.P.038.] --/8 points

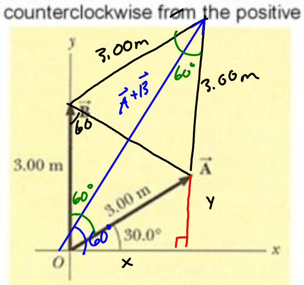
Each of the displacement vectors $\vec{A}$ and $\vec{B}$ shown in the figure below has a magnitude of 3.00 m. Find the following values graphically. Report all angles counterclockwise from the positive x axis. (Do this on paper. Your instructor may ask you to turn in this work.)

$\sin = \frac{O}{h}$

$\cos = \frac{a}{h}$

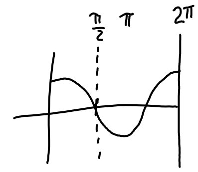
$\tan \frac{O}{a}$

$\cos(30) = \frac{a}{3}$



$30° \times \frac{\pi}{180} = \frac{\pi}{6}$

$6\cos\left(\frac{\pi}{6}\right)$



(a) $\vec{A} + \vec{B}$

$x = r\cos\theta$

$y = r\sin\theta$

$\vec{A}$

$x = 3\cos(30°)$

$y = 3\sin(30°)$

$\vec{B} : \langle 0, 3 \rangle$

$\vec{A} = \langle 3\cos\frac{\pi}{6}, 3\sin\frac{\pi}{6} \rangle$

$\langle 2.598, 1.5 \rangle$

magnitude 5.2 m
θ 60° °

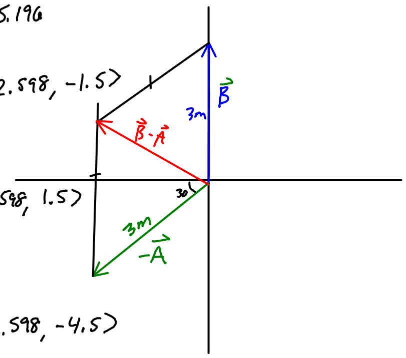
$\vec{A}+\vec{B} = \langle 2.598, 4.5\rangle$
5.196

(b) $\vec{A} - \vec{B}$
magnitude 3 m
θ 330 °

$\vec{A}-\vec{B}$ $\langle 2.598, -1.5\rangle$

(c) $\vec{B} - \vec{A}$
magnitude 3 m
θ 210 °

$\vec{B}-\vec{A} = \langle -2.598, 1.5\rangle$



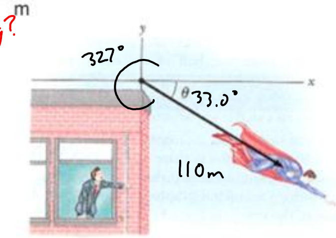
(d) $\vec{A} - 2\vec{B}$
magnitude 5.2 m
θ 300 °

$\vec{A}-2\vec{B} = \langle 2.598, -4.5\rangle$
5.196

5. [SerPOP4 1.P.040.] --/2 points

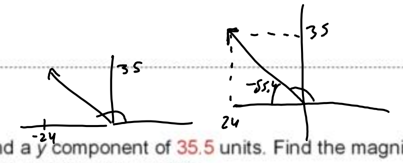
Find the horizontal and vertical components of the d = 110 m displacement of a superhero who flies from the top of a tall building following the path shown in the figure below where θ = 33.0°.

x = 92.3m m
y = -59.9 m
submit w/ neg?
360-33 =



$x = r\cos\theta$
$x = 110 \times \cos(327°)$
$x = 92.3\text{m}$

$y = r\sin\theta$
$= 110 \sin 327°$
$y = -59.9\text{m}$



6. [SerPOP4 1.P.041.AF.] --/2 points

A vector has an x component of -24.5 units and a y component of 35.5 units. Find the magnitude and direction of the vector.
43.1 units at -55.4 ° counterclockwise from the +x-axis

Hint: Active Figure 1.4

$\vec{x} = \langle -24.5, 35.5 \rangle$

$|\vec{x}| = \sqrt{(24.5)^2 + (35.5)^2} = 43.1$

$\tan\theta = \left(\frac{-35.5}{24.5}\right)$

$\theta = -55.4°$

7. [SerPOP4 1.P.042.AF.] --/9 points

Given the vectors $\vec{A} = 3.00\hat{i} + 6.00\hat{j}$ and $\vec{B} = 3.00\hat{i} - 6.00\hat{j}$.

(a) Draw the vector sum $\vec{C} = \vec{A} + \vec{B}$ and the vector difference $\vec{D} = \vec{A} - \vec{B}$. (Do this on paper. Your instructor may ask you to turn the paper in.)

(b) Calculate $\vec{C}$ and $\vec{D}$, first in terms of unit vectors.

$\vec{C} =$ 6 $\hat{i} +$ 0 $\hat{j}$

$\vec{D} =$ 0 $\hat{i} +$ 12 $\hat{j}$

Calculate $\vec{C}$ and $\vec{D}$ in terms of polar coordinates, with angles measured with respect to the +x axis.

vector $\vec{C}$

r = 6 $\bar{C} = \langle 6, 0 \rangle$

$\theta =$ 0 °

vector $\vec{D}$

r = 12

$\theta =$ 90 °

Hint: Active Figure 1.3

8. **[SerPOP4 1.P.043.AF.] --/2 points**

A man pushing a mop across a floor causes it to undergo two displacements. The first has a magnitude of 158 cm and makes an angle of 115° with the positive *x* axis. The resultant displacement has a magnitude of 130 cm and is directed at an angle of 30.0° to the positive *x* axis. Find the magnitude and direction of the second displacement.

195 cm

337 ° (counterclockwise from the positive *x* axis)

Hint: Active Figure 1.9

$|\vec{A}| = 158\text{cm}$ $\theta = 115°$

$|\vec{B}| = 130$ $\theta = 30.0°$

$\vec{A} + \vec{C} = \vec{B}$

$\vec{C} = \vec{B} - \vec{A}$

$\vec{A}_x = 158\cos(115°) = -66.8\text{cm}$

$\vec{A}_y = 158\sin(115°) = 143\text{cm}$

$\vec{B}_x = 130\cos(30°) = 112\text{ cm}$

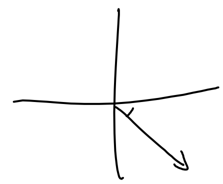
$\vec{B}_y = 130\sin(30°) = 65.0\text{cm}$

$\vec{C} = 179i - 78.0j$

$|\vec{C}| = 195\text{cm}$

$\tan\theta = \frac{y}{x}$ $\theta = -23.5°$

$360 - 23.5°$



9. **[SerPOP4 1.P.045.] --/8 points**

Consider two vectors $\vec{A} = 5\hat{\imath} - 3\hat{\jmath}$ and $\vec{B} = -\hat{\imath} - 6\hat{\jmath}$.

(a) Calculate $\vec{A} + \vec{B}$

4 $\hat{\imath}$ + −9 $\hat{\jmath}$

(b) Calculate $\vec{A} - \vec{B}$

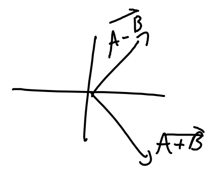
6 $\hat{\imath}$ + 3 $\hat{\jmath}$

(c) Calculate $|\vec{A} + \vec{B}|$ $\sqrt{16+81} = \sqrt{97} = 9.8489$

(d) Calculate $|\vec{A} - \vec{B}|$ $\sqrt{36+9} = \sqrt{45} = 6.708$

(e) What is the direction of $\vec{A} + \vec{B}$?

294 ° (from the +*x* axis) $\tan\theta = \frac{y}{x}$ $\theta = -66.04$ $360 - 66$



(f) What is the direction of $\vec{A} - \vec{B}$?

26.6 ° (from the +*x* axis) $\tan^{-1}(.5)$

10. [SerPOP4 1.P.044.] --/2 points

Vector $\vec{A}$ has x and y components of -8.60 cm and 17.0 cm, respectively; vector $\vec{B}$ has x and y components of 14.0 cm and -7.00 cm, respectively. If $\vec{A} - \vec{B} + 3\vec{C} = 0$, what are the components of $\vec{C}$?

x = 7.53 cm

y = −8.00 cm

$$-8.6i + 17.0j - (14i - 7j) + 3(\vec{C}) = 0$$

$$-22.6i + 24j = -3(\vec{C})$$

$$\vec{C} = 7.5\bar{3}i - 8j$$

Lecture 10/01

Wednesday, October 01, 2008
11:00 AM

Scalars	Vectors
Magnitude Temperature, mass	Magnitude + direction

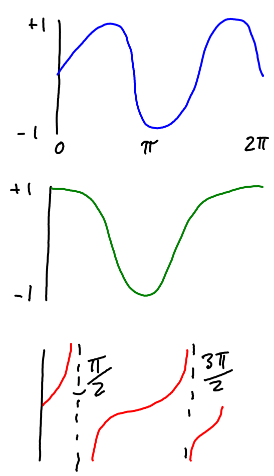
$2\pi = 360°$

$$A_x = A\cos\theta \qquad \tan\theta = \frac{A_y}{A_x}$$
$$A_y = A\sin\theta$$

$\sin\theta$

$\cos\theta$

$\tan\theta$



$A_x < 0$ $A_y > 0$	$A_x > 0$ $A_y > 0$
$A_x < 0$ $A_y < 0$	$A_x > 0$ $A_y < 0$

Unit Vectors

$$|\hat{i}| = 1$$
$$|\hat{j}| = 1$$

$$\vec{A} = A_x\hat{i} + A_y\hat{j}$$

$$A \text{ or } |\vec{A}| = \sqrt{A_x^2 + A_y^2 + A_z^2}$$

$$\cos\theta_x = \frac{A_x}{A}$$

Example

particle: 3 successive displacements

$\vec{r}_1, \vec{r}_2, \vec{r}_3$

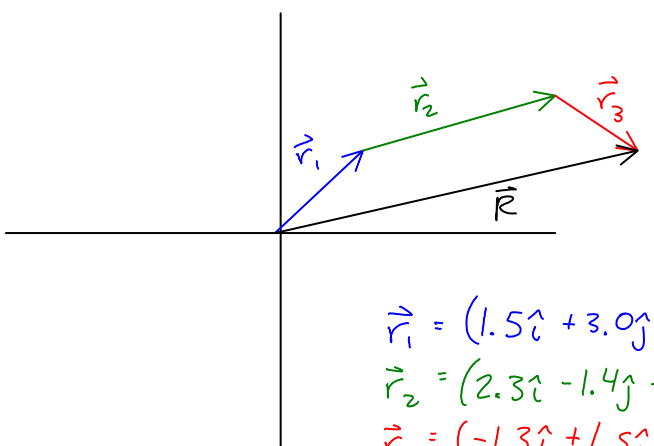
total displacement $\vec{R}$

magnitude + components

$r_1 = (1.5, 3.1, -1.2)\,cm$

$r_2 = (2.3, -1.4, -3.6)\,cm$

$r_3 = (-1.3, -1.5, 0)\,cm$



$\vec{r}_1 = (1.5\hat{i} + 3.0\hat{j} - 1.2\hat{k})\,cm$

$\vec{r}_2 = (2.3\hat{i} - 1.4\hat{j} - 3.6\hat{k})\,cm$

$\vec{r}_3 = (-1.3\hat{i} + 1.5\hat{j})\,cm$

$\vec{R} = (2.5\hat{i} + 3.1\hat{j} - 4.8\hat{k})\,cm$

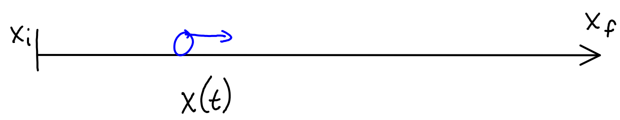
$R = \sqrt{(2.5)^2 + (3.1)^2 + (-4.8)^2}$

$=$

$$R = \sqrt{(2.5)^2 + (3.1)^2 + (-4.8)^2}$$
$$=$$

Kinematics - Ch II

language of motion



Average Velocity

$$v_{AV} = \frac{\Delta x}{\Delta t}$$

Lecture 10/03

Friday, October 03, 2008
11:04 AM

Speed = positive
Velocity = positive or negative
Instantaneous velocity -

BBOOOORRREEEEDDDD!

Lecture 10/06

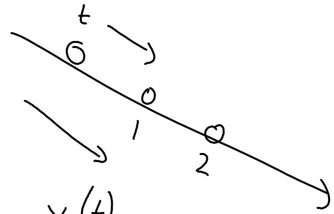
Monday, October 06, 2008
10:59 AM

Speed is always positive
Velocity can be positive or negative

Free fall

$x(t)$

Galilei



$x(t)$
$v(t)$

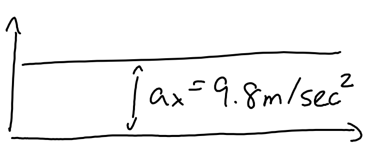
$$x(t) = \text{cons}\ t^2$$
$$v_x(t) = \text{cons}\ t$$

$$a_x = \frac{dV_x}{dt} = \text{cont}$$
$$a_x = 9.8\ m/sec^2$$

constant velocity

$$\boxed{x(t) = x_1 + v_x t}$$

a_x constant acceleration



constant acceleration

(1) $$\boxed{v_x(t) = v_{x_1} + a_x t}$$

(2) $$\boxed{v_{x,\text{averge}} = \frac{1}{2}(v_{x_1} + v_{xf})}$$ (or $\frac{\Delta x}{\Delta t}$)

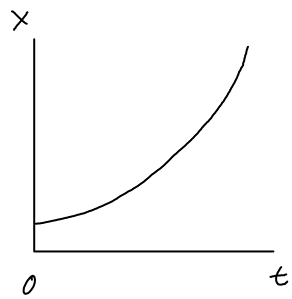
$$X(t_f) = x_i + (v_{x,av})t_f$$
$$= x_i + \frac{1}{2}(v_{x_i} + \underbrace{v_{xf}}_{v_{xi} + a_x t_f})t_f$$

constant acceleration

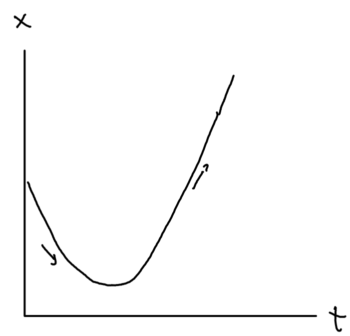
③ $$\boxed{x(t_f) = x_i + v_{xi}\, t_f + \frac{1}{2} a_x t_f^2}$$

position vs time

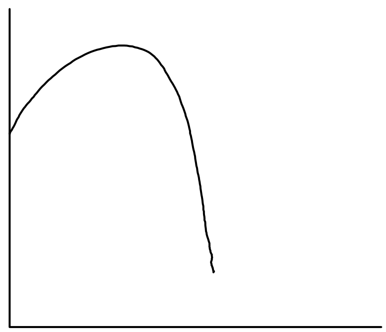
Ex. $v_{xi} > 0$
$a_x > 0$



Ex $v_{xi} < 0$
$a_x > 0$



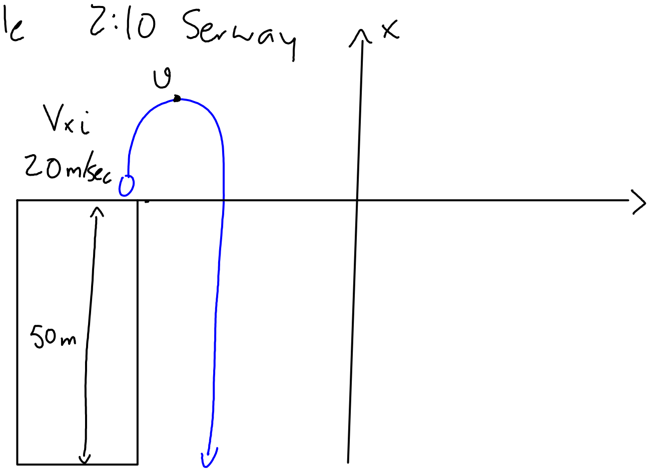
Ex $v_{xi} > 0$
$a_x < 0$



④ $$\boxed{v_x^2(x) = v_{xi}^2 + 2a_x(x - x_i)}$$

$\left(\frac{m}{sec}\right)^2 \qquad \frac{m^2}{sec^2} \qquad \frac{m}{sec^2} \times m$

Example 2:10 Serway



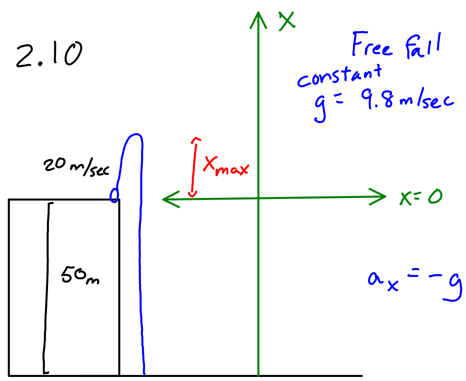
0

Lecture 10/08

Wednesday, October 08, 2008
11:00 AM

1) $V_x(t) = V_{xi} + a_x t$
2) $x(t) = x_i + V_{xi} t + \frac{1}{2} a_x t^2$
3) $v_{ave} = \frac{1}{2}(v_{xi} + v_{xf})$
4) $v_x^2(x) = v_{xi}^2 + 2a_x(x - x_i)$

Example 2.10



a) When is $x(t)$ at the maximum

when $v_x = 0$ t = time

$v_x(t_{max}) = 20 - g(t_{max}) = 0$

$t_{max} = 2.04 \text{ sec}$

b) What is x_{max}?

$x_{max} = x_i + v_{xi} t_{max} - \frac{1}{2} g t_{max}^2$

$= 0 + 20 \times 2.04 - (9.8)(2.04)^2$

$= 2.04$

c) At what t_0 is the ball each as $x = 0$

$x(t) = x_i + v_{xi} t - \frac{1}{2} g t^2$

$0 = 20t - \frac{1}{2} g t^2$

$0 = t(20 - \frac{1}{2} g t)$

$t = 0, \frac{40}{g}$

d) When does ball strike ground

$x(t) = -50$

$-50 = 20t - \frac{1}{2} g t^2$

$0 = \frac{1}{2} g t^2 - 20t - 50$

$t = \dfrac{20 \pm \sqrt{400 + 4 \cdot \frac{1}{2} g \cdot 50}}{(2)(\frac{1}{2} g)}$

$t = 5.8 \text{ sec}$

Motion in $d = 2$ Ch. III

$\vec{r}(t) = ((x(t), y(t))$

$v_x = \dfrac{dx}{dt}$

$v_{av} = \dfrac{\Delta x}{\Delta t}$

Homework #2

Wednesday, October 08, 2008
11:35 AM

WebAssign

Homework Ch.2 (Homework)

HEATHER CATHERINE GRAEHL
Physics 6A, Fall 2008
Instructor: Robijn Bruinsma

Current Score: 0 out of 25
Due: Monday, October 13, 2008 11:59 PM PDT

Description
Assignment 2

---

1. [SerPOP4 2.P.001.] --/3 points

The position of a pinewood derby car was observed at various times; the results are summarized in the following table. Find the average velocity of the car for the following time periods.

t (s)	0	1.0	2.0	3.0	4.0	5.0
x (m)	0	2.3	10.2	17.7	39.1	61.0

(a) during the first second

$\frac{2.3}{1} = 2.3$

2.3 m/s

(b) during the last 3 s $\frac{61 - 10.2}{3} = 16.9\bar{3}$

16.9 m/s

(c) during the entire period of observation

12.2 m/s $\frac{61}{5}$

---

2. [SerPOP4 2.P.003.AF.] --/5 points

The position versus time for a certain particle moving along the x axis is shown in Figure P2.3.

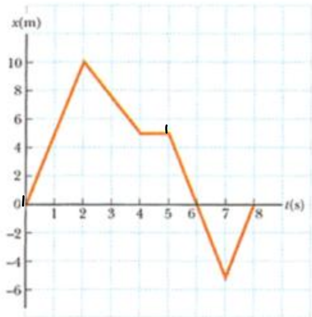


Figure P2.3

Find the average velocity in the following time intervals.

(a) 0 to 5 s
1 m/s $\frac{5-0}{5} = 1$

(b) 0 to 6 s
0 m/s

(c) 5 s to 6 s
−5 m/s $\frac{0-5}{1} = -5$

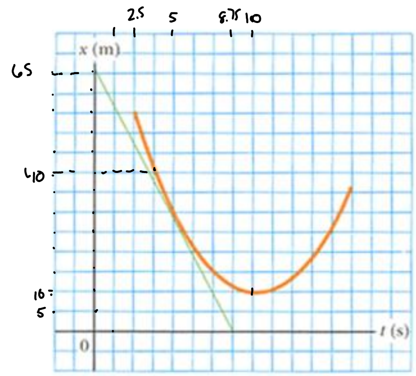
(d) 6 s to 7 s
−5 m/s $\frac{-5-0}{1} = -5$

(e) 0 to 8 s
m/s

Hint: Active Figure 2.2

3. [SerPOP4 2.P.005.] --/3 points

A position-time graph for a particle moving along the *x* axis is shown in the figure. The divisions along the horizontal axis represent 1.25 s and the divisions along the vertical axis represent 5.0 m.



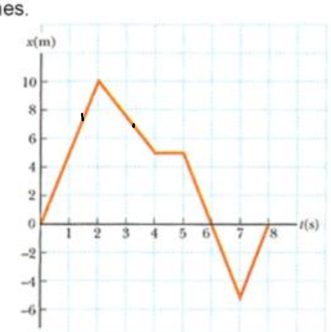
(a) Find the average velocity in the time interval t = 3.75 s to t = 10.00 s.
4.8 m/s $\frac{10-40}{10-3.75}$ $\frac{30}{6.25}$ = .48

(b) Determine the instantaneous velocity at t = 5.00 s (where the tangent line touches the curve) by measuring the slope of the tangent line shown in the graph.
-7.43 m/s $\frac{-65}{8.75}$ = -7.43

(c) At what value of t is the velocity zero?
10 s

4. [SerPOP4 2.P.008.] --/4 points

Find the instantaneous velocity of the particle described in the figure below at the following times.



(a) t = 1.5 s
5 m/s

$\frac{5-10}{4-2} = \frac{-5}{2}$

(b) t = 3.3 s
-2.5 m/s

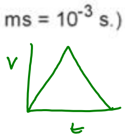
(c) t = 4.2 s
0 m/s

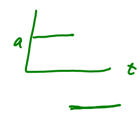
(d) t = 7.4 s
5 m/s

5. [SerPOP4 2.P.010.AF.] --/1 points

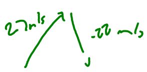
A 45.0 g superball traveling at 27.0 m/s bounces off a brick wall and rebounds at 22.0 m/s. A high-speed camera records this event. If the ball is in contact with the wall for 3.50 ms, what is the magnitude of the average acceleration of the ball during this time interval? (Note: 1 ms = 10^{-3} s.)

m/s^2 0.00355





Hint: Active Figure 2.8



6. [SerPOP4 2.P.013.] --/3 points

A particle moves along the x axis according to the equation $x = 2.10 + 3.00t - t^2$, where x is in meters and t is in seconds.

(a) At t = 2.80 s, find the position of the particle.
2.66 m

$x = 2.10 + (3.00)(2.8) - (2.8)^2$ 7.84

(b) What is its velocity at t = 2.80 s? $x'(t) = 3 - 2t$
-2.6 m/s

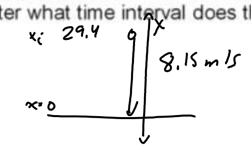
(c) What is its acceleration at t = 2.80 s?
-2 m/s^2 $x''(t) = -2$

7. [SerPOP4 2.P.032.] --/1 points 8.5

A ball is thrown directly downward, with an initial speed of 8.15 m/s, from a height of 29.4 m. After what time interval does the ball strike the ground?

s 32.2

$m' - \frac{m t}{s} - \frac{m}{s^2} t^2$



$x(t) = 29.4 - 8.15t - \frac{1}{2} g t^2$

$0 = -4.9t^2 - 8.15t + 29.4$

$t = \frac{8.15 \pm \sqrt{66.4225 + 576.24}}{(2)(-4.9)}$

$\frac{8.15 - 25.35}{-9.8}$

8. [SerPOP4 2.P.029.] --/2 points

A baseball is hit so that it travels straight upward after being struck by the bat. A fan observes that it takes 2.80 s for the ball to reach its maximum height.

(a) Find its initial velocity.
m/s (upward)

(b) Find the height it reaches.
m

$x_f = x_i + \frac{1}{2}(v_{x_f} + v_{x_i})t$

$x_f = 0 + \frac{1}{2}($

pos

9.8 $\vec{g}$

$\vec{a}$ bat $\vec{g}$

$x(t) = h - v_{int}t - 4.9t^2$

$x'(t) = -v_{init} - 9.8t$

$v_{int} = 27.44$

38.416

$27.44t + \frac{1}{2}a_x t^2$

x

$x=0$

$x(2.8) =$ max height

$x'(2.8) = 0$

9. [SerPOP4 2.P.023.] --/1 points

The driver of a car slams on the brakes when he sees a tree blocking the road. The car slows uniformly with acceleration -5.85 m/s^2 for 4.30 s, making straight skid marks 60.7 m long ending at the tree. With what speed does the car then strike the tree?
m/s

$-5.85\frac{m}{s^2} \times 4.3s = -25.155\frac{m}{s}$ Δv

$60.7 = 0 + v_x t - \frac{1}{2}5.85t^2$

$60.7 = -v_x t - 54.08325$

$x_i = -26.694$

accel $v_{x_f} =$

pos. $x(t)$ 0 x_i 60.7 x_f

velocity m/s

accel const $-5.85 m/s^2$

v vs t

acceleration vs t $-5.85 m/s^2$

10. [SerPOP4 2.P.022.] --/2 points

A particle moves along the x axis. Its position is given by the equation x = 2.20 + 3.00t - 3.80t^2 with x in meters and t in seconds.

(a) Determine its position when it changes direction.
2.79 m

(b) What is its velocity when it returns to the position it had at t = 0?
-3.07 m/s

$t=0 \rightarrow x = 2.20$

$x'(t) = 3 - (2)(3.8)t$

$0 = 3 - 7.6t$

$t = 0.395$

$3.00t - 3.80t^2 = 0$

$t(3 - 3.8t) = 0$

$t = 0$

$t = 0.78947$

$x = 2.20 + 1.185 - 0.593$

$= 2.79$

$t = \frac{-3 \pm \sqrt{9 + (4)(2.2)(3.8)}}{(2)(-3.8)}$ $t = \frac{-3 \pm 6.51}{2 \times 2.2} = \frac{3.51}{2 \times 2.2} = 0.799$

Lecture 10/10

Friday, October 10, 2008
11:03 AM

Motion in Two Dimensions
"Vector kinematics"

$$\vec{r}(t) = (x(t), y(t)) = \hat{\imath}\, x(t) + \hat{\jmath}\, y(t)$$

$$\vec{v}(t) = (V_x(t), V_y(t)) = \left(\frac{dx}{dt}, \frac{dy}{dt}\right)$$

$$\vec{a} = \left(\frac{dv_x}{dt}, \frac{dv_y}{dt}\right)$$

Constant acceleration

$$v(t) = v_1 + at$$

1) $\vec{v}(t) = \vec{v}_1 + \vec{a}t$

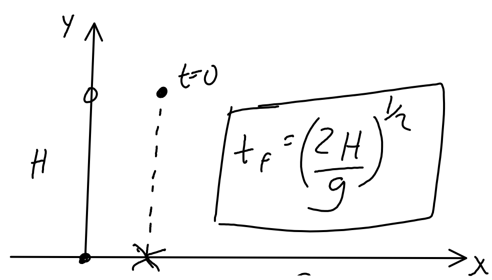
2) $\vec{x}(t) = \vec{x}_i + \vec{v}_i t + \frac{1}{2}\vec{a}_i t^2$

$$v_x(t) = v_{x_i} + a_x t$$
$$v_y(t) = v_{y_i} + a_y t$$

$$x(t) = x_i + v_{x_i} t + \frac{1}{2} a_x t^2$$
$$y(t) = y_i + v_{y_i} t + \frac{1}{2} a_y t^2$$

$\left.\begin{matrix}\vec{x}_i \\ v_i\end{matrix}\right\}$ determine motion

$$\vec{a} = (0, -9.8\ g/sec^2) = \vec{g}$$

i) 

$$\boxed{t_f = \left(\frac{2H}{g}\right)^{1/2}}$$

$x_1 = 0, \quad y_1 = H$

$v_{x_i} = v_{y_1} = 0$

$a_x = 0 \quad a_y = -g$

$x(t) = 0$

$y(t) = H - \frac{1}{2}gt^2$

$t = t_f$

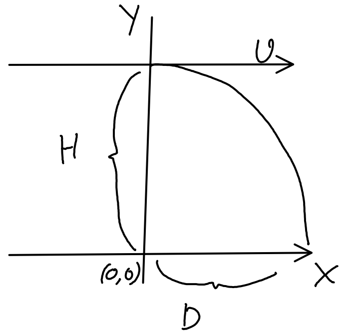
$y(t_f) = 0$

$H = \frac{1}{2}g t_f^2$

$y(t) = H - \frac{1}{2}gt^2$

$H = \frac{1}{2}gt_f^2$

ii)



What is D?

$x(t) = vt$

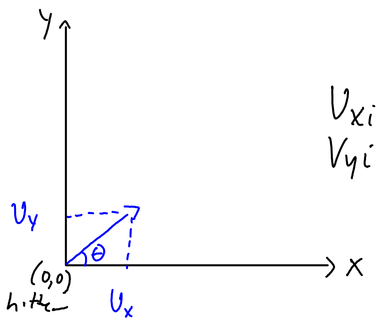
$y(t) = H - \frac{1}{2}gt^2$

$D = v t_f$

$D = v\left(\frac{2H}{g}\right)^{1/2}$

iii) Range R of a baseball

$v \approx 100\text{mph}$



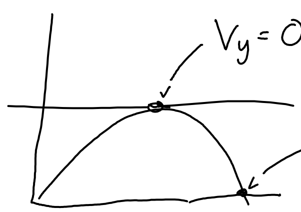
$v_{xi} = v\cos\theta$

$v_{yi} = v\sin\theta$

$x(t) = v\cos\theta\, t$

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

a) What time t_{max} does $y(t)$ reach highest value?



$t_f = 2t_{max}$ <- range is x at this time

$v_y(t_{max}) = v\sin\theta - gt_{max} = 0$

$R = x(t_f) = x(2t_{max})$

$= v\cos\theta \times \frac{2v\sin\theta}{g}$

$$\boxed{R = 2\sin\theta\cos\theta\frac{v^2}{g}}$$

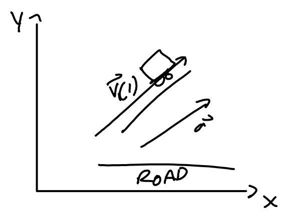
Notes 10/13

Monday, October 13, 2008
11:10 AM

Fixed speed

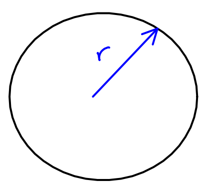
$$\vec{a} = \frac{d\vec{v}}{dt}$$

1) $\vec{a}$ not constant: Fixed direction



$$|\vec{a}| = \frac{d\,|\vec{v}|}{dt}$$

$$\vec{a}_{AV} = \frac{\vec{v}(2) - \vec{v}(1)}{\Delta t}$$



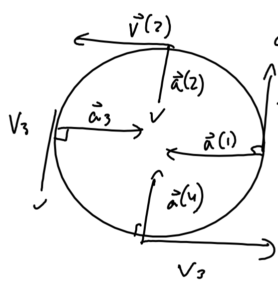
T
time for one circle

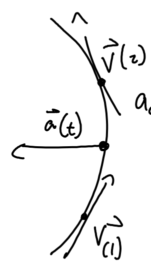
$$V = \frac{2\pi r}{T}$$

$$|\vec{V}(1)| = |\vec{V}(2)| = |\vec{V}(3)|$$

uniform circular motion

constant speed





a_c = centrifigal acceleration towards center!

v Speed
what could magnitude ac depend on

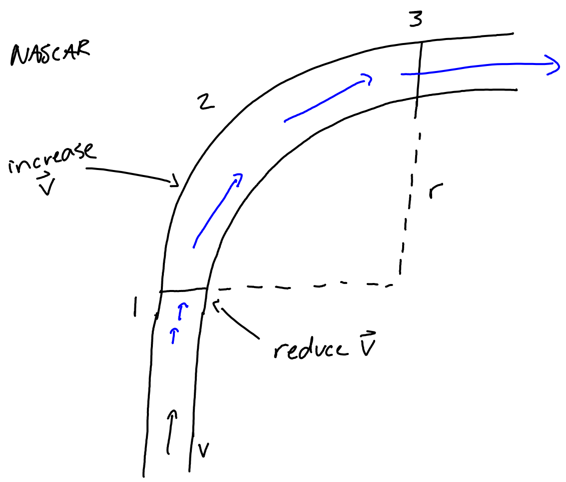
a_c: radius r $\quad a_c(\to 0)$ if $(r \to \infty)$

a_c: depend on v $(a_c(v \to 0) = 0)$
$(l/t)(l)$
$a_c = (v, r)$
l/t^2

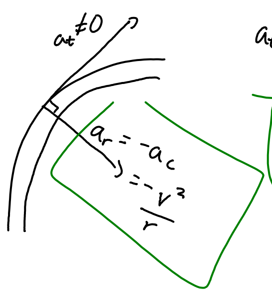
ℓ/t^2

$$\frac{v^2}{\ell} \sim \frac{\ell^2}{t^2} \qquad \text{so} \qquad \frac{v^2}{r} \sim \frac{\ell}{t^2}$$

$$a_c = \frac{v^2}{r}$$

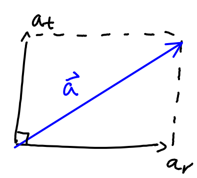


magnitude and direction of v change

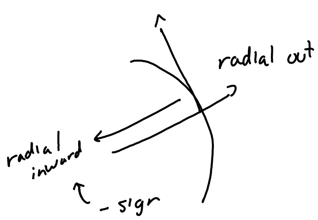


$$a_t = \frac{d|\vec{v}|}{dt}$$

$$\boxed{= \frac{d\theta}{dt}}$$

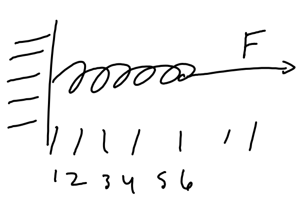


$$|\vec{a}| = \sqrt{a_r^2 + a_t^2}$$



Force

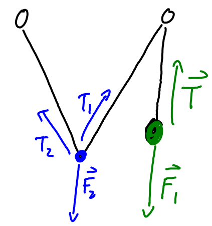
* What causes motion
* Measure force with spring gauge



units F?
"Newton" or N

2) weight
↑
Force

1kg → 10 Newton

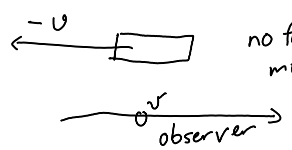


$\vec{T} + \vec{F}_1 = 0$

$T_1 + T_2 + F_2 = 0$

* electrical force

⊕ → ← ⊖



no force! moves!

An object can move with constant velocity with no force being exerted!

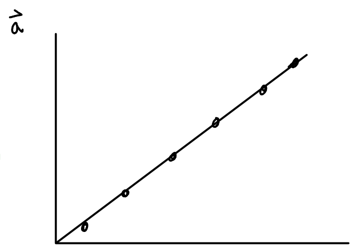
First Law of Motion:
If an object is not interacting with other objects then it moves with constant velocity

Rephrase: if an object is not interacting with other objects then you can find a frame of reference with acceleration = 0.

$\vec{F}_t$ ← net force on objects

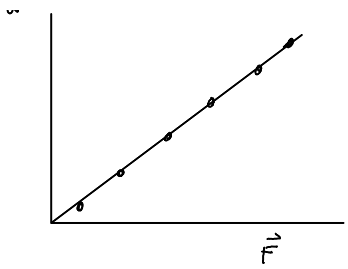
if $\boxed{\vec{F}_t \neq 0 \longrightarrow \vec{a} \neq 0}$
experiment

2nd law
$\vec{a} \propto \vec{F}_T$



2nd law

$\vec{a} \propto \vec{F}_T$



Notes 10/15

Wednesday, October 15, 2008
10:57 AM

Midterm Review Th 5-7
Frans hall 1260

Midterm AL - FRANS 1178

Can bring 1 page equation sheet

Laws of Motion

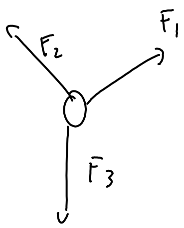
Force $\vec{F}$ Vector Newton

<u>Fundamental</u>

* Electrical, Magnetic
* gravitational
* nuclear

Macroscopic Forces

* spring force $\vec{F}$
* tension force $\vec{F}$
* Contact force



Total force on object $\vec{F_1} + \vec{F_2} + \vec{F_3}$

NI

$F_t = 0$

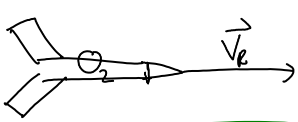
If $F_t = 0$ on an object then it moves with constant velocity.

What is the constant velocity in NI?

(look frame of reference)

asteroid $\vec{V_A}$ measured with respect to earth frame of reference

$F_T = 0$



(velocity with respect to earth

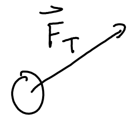
$$\boxed{\vec{V_A}' = \vec{V_A} - \vec{V_R}}$$ velocity of asteroid for O_2

*Inertial fram of reference
-> reference frame for which N1 (newton's 1st law) is valid.
IFR

- Is earth an IFR? No - it spins and rotates
- Rocket is an IFR if engine is off (not accelerating)
- Newton said use fixed stars are good IFR. Based coordinate system based on fixed stars.

N2

Total force on object $\vec{F}_T \neq 0$



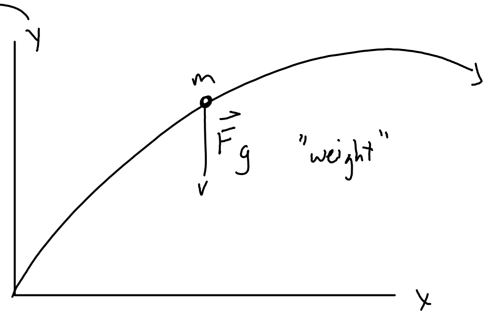
$\vec{a}$: acceleration

If $\vec{F}_T \neq 0$ then object accelerates $\boxed{\vec{a} \propto \vec{F}_T}$

$$\boxed{\vec{a} = \left(\frac{1}{m}\right)\vec{F}_T}$$ ← total force

inertial $\boxed{\text{mass}}$ inherent

Example 1



Force exerted by Earth on object is the weight

$$\vec{W} = \boxed{\vec{F}_g = m\vec{g}}$$ gravitational mass

$$\vec{g} = (0, -9.8\,m/sec)$$

What is acceleration of the object

$$\vec{a} = \left(\frac{1}{m}\right) \times (m\vec{g}) = \vec{g}$$

if $m = 5kg$

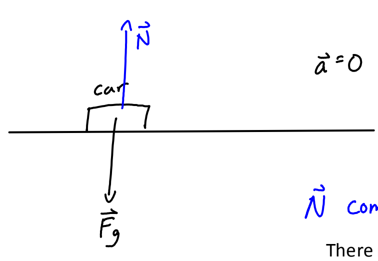
$$|\vec{F}_g| = 9.8 \times 5 \cong 25N$$

Weight in Newtons!

Units:
Weight is a force, expressed in N. EXTRINSIC

Mass: expressed in kg. INTRINSIC

Example 2:



$\vec{a} = 0$ so $\vec{F}_T = 0$

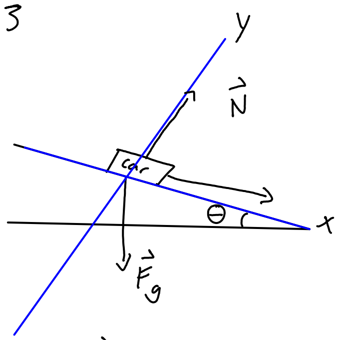
$\vec{N}$ compensating force because not moving

There must be a second force "N" that compensates

$\vec{N} = -\vec{F_g}$

N = reaction force (aka normal force) by the track on the car

Example 3



$\vec{F_g} = mg$

Two forces only

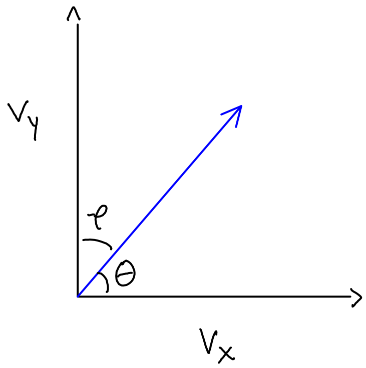
object moves along x direction

$\vec{F}_T = \vec{N} + \vec{F_g} \neq 0$

$\vec{F}_{Tx} \neq 0, \quad \vec{F}_{TY} = 0$

Review Session Midterm 1

Thursday, October 16, 2008
5:01 PM



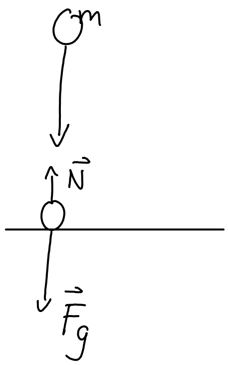
$$\vec{x}(t) = \vec{x}_0 + \vec{v}_0 t + \frac{1}{2}\vec{a}t^2$$
$$\vec{v}(t) = \vec{v}_0 + \vec{a}t$$
$$V_f^2 - V_i^2 = 2\vec{a}\Delta x \quad \text{(1 dimention only)}$$

$$V_x = v\cos\theta = v\sin\varphi$$
$$V_y = v\sin\theta = v\cos\varphi$$

$$|v| = \frac{2\pi R}{T}$$
$$|a|_{cent} = \frac{4\pi^2 R}{T^2} = \frac{2\pi|v|}{T} = \frac{2\pi|v|}{T} = \frac{|v|^2}{R}$$

Notes 10/17

Friday, October 17, 2008
11:04 AM



$\vec{F}_g = m\vec{g}$

Laws of Motion

N1) If $\vec{F}_T = 0$ (no interaction)
then $a = 0$

N2) If $\vec{F}_T \neq 0$ then it accelerates

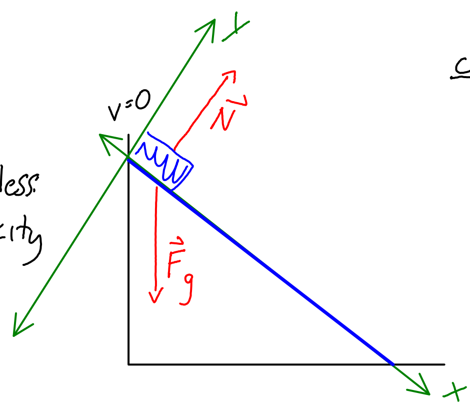
$$\vec{a} = \left(\frac{1}{m}\right)\vec{F}_T$$

mass ON

$\boxed{\text{1 Newton = force produces } a = 1\,m/sec^2 \text{ if } m = 1\,kg}$

1) Diagram, choose coordinate system, chose system
2) Free body force diagram ON system

Example
frictionless
what is velocity at bottom?



common sense

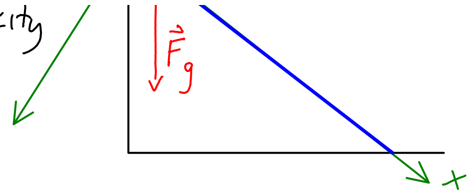
$N_x = 0$

$a_y = 0$

Solve $\sum F_{x_i} = ma_x$

$\sum F_{y_i} = ma_y$

what is velocity at bottom?



Solve $\sum F_{x_i} = ma_x$

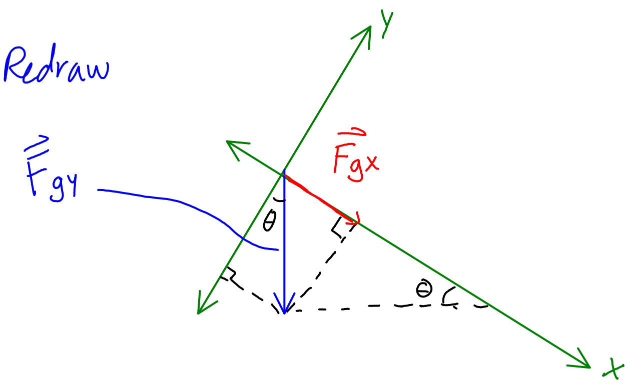
$\sum F_{y_i} = ma_y$

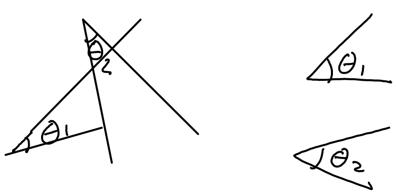
$\vec{F}_g \, , \, \vec{N}$

$F_{gx} + N_x = Ma_x \longrightarrow F_{gx} + 0 = Ma_x$

$F_{gy} + N_y = Ma_y \qquad F_{gy} + N_y = 0$

Redraw





$\theta_1 = \theta_2$ if "legs" of angles are $\perp$

$F_{gx} = Mg\sin\theta \qquad F_{gy} = -Mg\cos\theta$

$Mg\sin\theta = Ma$

$a = g\sin\theta$

$-Mg\cos\theta + N = 0$

$N = Mg\cos\theta$

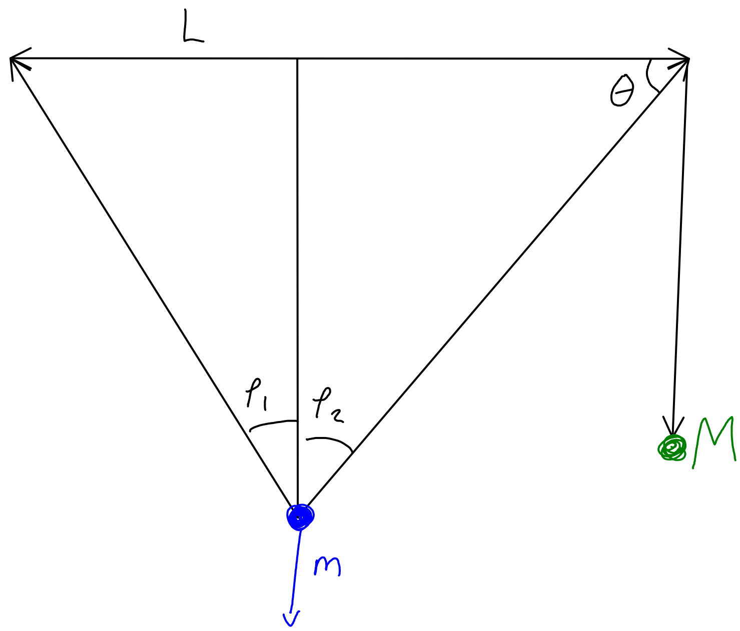
$x(t) = x_0 + v_0 t + \frac{1}{2}at^2$

$x(0) = v_0 = 0$

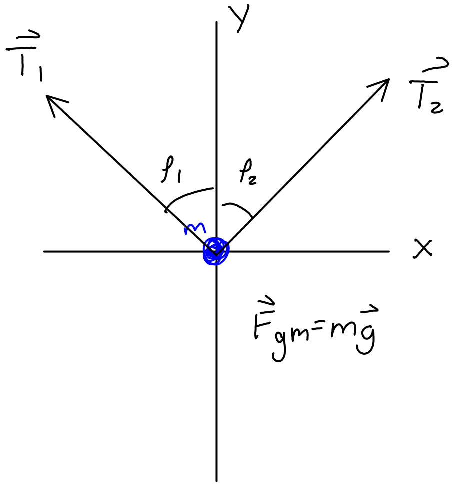
$x(0) = v_1 = 0$

$x(t) = \frac{1}{2} g \sin\theta \, t^2$

$v(t) = g \sin\theta \, t$



Tension T in a rope that runs over a free pulley is the same

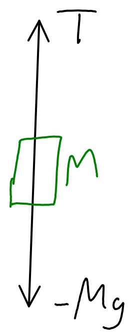


Forces $\vec{T}_1 \; \vec{T}_2 \; \vec{F}_{mg}$

$$\vec{T}_{1x} + \vec{T}_{2x} = m\vec{a}_x$$

$$\vec{T}_{1y} + \vec{T}_{2y} - mg = ma_y = 0$$

unknowns: $\vec{T}_1 \; \varphi_1 \; \varphi_2$



$$T - Mg = Ma_y = 0$$
$$T = Mg$$

$$\underbrace{-T\sin\theta_1}_{T_{1x}} + \underbrace{T\sin\theta_2}_{T_{2x}} = 0$$

so $\theta_1 = \theta_2$

$$T\cos\theta + T\cos\theta = mg$$

$$T = Mg$$
$$2T\cos\theta = mg$$
$$\cos\theta = mg$$

Homework #3

Friday, October 17, 2008
3:58 PM

WebAssign

Homework Ch.3 (Homework)

HEATHER CATHERINE GRAEHL
Physics 6A, Fall 2008
Instructor: Robijn Bruinsma

Current Score: 0 out of 29
Due: Sunday, October 19, 2008 08:00 PM PDT

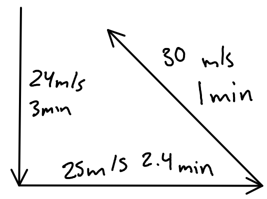
1. [SerPOP4 3.P.001.] --/5 points

A motorist drives south at 24.0 m/s for 3.00 min, then turns west and travels at 25.0 m/s for 2.40 min, and finally travels northwest at 30.0 m/s for 1.00 min. For this 6.40 min trip, find the following values.

(a) total vector displacement
______ m (magnitude) ______ ° south of west

(b) average speed
______ m/s

(c) average velocity
______ m/s (magnitude) ______ ° south of west



$x(t) = x_0 +$

2. [SerPOP4 3.P.003.] --/6 points

A fish swimming in a horizontal plane has velocity $\mathbf{v}_i = (4.00\,\mathbf{i} + 2.00\,\mathbf{j})$ m/s at a point in the ocean where the position relative to a certain rock is $\mathbf{r}_i = (10.0\,\mathbf{i} - 4.00\,\mathbf{j})$ m. After the fish swims with constant acceleration for 20.0 s, its velocity is $\mathbf{v} = (21.0\,\mathbf{i} - 5.00\,\mathbf{j})$ m/s.

(a) What are the components of the acceleration?
$a_x =$ ______ m/s^2
$a_y =$ ______ m/s^2

(b) What is the direction of the acceleration with respect to unit vector **i**?
______ ° (counterclockwise from the +x-axis is positive)

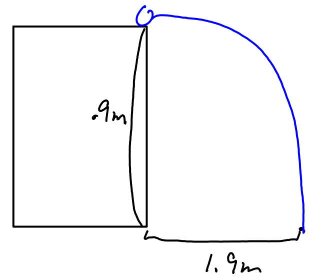
(c) If the fish maintains constant acceleration, where is it at t = 27.0 s?
$x =$ ______ m
$y =$ ______ m
In what direction is it moving?
______ ° (counterclockwise from the +x-axis is positive)

3. [SerPOP4 3.P.007.AF.] --/2 points

In a local bar, a customer slides an empty beer mug down the counter for a refill. The bartender is just deciding to go home and rethink his life. He does not see the mug, which slides off the counter and strikes the floor 1.90 m from the base of the counter. The height of the counter is 0.900 m. (Ignore air resistance.)

(a) With what velocity did the mug leave the counter?
m/s

(b) What was the direction of the mug's velocity just before it hit the floor?
° (below the horizontal)



Hint: Active Figure 3.5

$x(t) = x_0 + V_0 t + \frac{1}{2} a t^2$

$= 0 + V_0 t + \frac{1}{2} a t^2 = V_0 t$

$y(t) = 0 + V_0 t + \frac{1}{2} a t^2$

$y(t) = -4.9t^2$

4. [SerPOP4 3.P.009.] --/1 points

Mayan kings and many school sports teams are named for the puma, cougar, or mountain lion *Felis concolor*, the best jumper among animals. It can jump to a height of 10.9 ft when leaving the ground at an angle of 40.4°. With

what speed, in SI units, does it leave the ground to make this leap?
m/s

5. [SerPOP4 3.P.010.] --/1 points

An astronaut on a strange planet finds that she can jump a maximum horizontal distance of 10.0 m if her initial speed is 2.40 m/s. What is the free-fall acceleration on the planet?
m/s^2

6. [SerPOP4 3.P.012.] --/3 points

A ball is tossed from an upper-story window of a building. The ball is given an initial velocity of 7.90 m/s at an angle of 25.0° below the horizontal. It strikes the ground 5.00 s later.

(a) How far horizontally from the base of the building does the ball strike the ground?
m

(b) Find the height from which the ball was thrown.
m

(c) How long does it take the ball to reach a point 10.0 m below the level of launching?

s

7. [SerPOP4 3.P.022.] --/1 points

Consider a planet of radius 7.38×10^6 m with a rotation period of 23.7 hours. Compute the radial acceleration of a point on the surface of the planet at the equator due to its rotation about its axis.

m/s^2 (directed toward the center of the planet)

8. [SerPOP4 3.P.024.] --/1 points

Casting of molten metal is important in many industrial processes. Centrifugal casting is used for manufacturing pipes, bearings, and many other structures. A variety of sophisticated techniques have been invented, but the basic idea is as illustrated in Figure P6.12. A cylindrical enclosure is rotated rapidly and steadily about a horizontal axis. Molten metal is poured into the rotating cylinder and then cooled, forming the finished product. Turning the cylinder at a high rotation

rate forces the solidifying metal strongly to the outside. Any bubbles are displaced toward the axis, so unwanted voids will not be present in the casting. Sometimes it is desirable to form a composite casting, such as for a bearing. Here a strong steel outer surface is poured, followed by an inner lining of special low-friction metal. In some applications, a very strong metal is given a coating of corrosion-resistant metal. Centrifugal casting results in bonding between the layers.

Suppose that a copper sleeve of inner radius 2.03 cm and outer radius 2.17 cm is to be cast. To eliminate bubbles and give high structural integrity, the centripetal acceleration of each bit of metal should be 100*g*. What rate of rotation is required? State the answer in revolutions per minute.

rpm

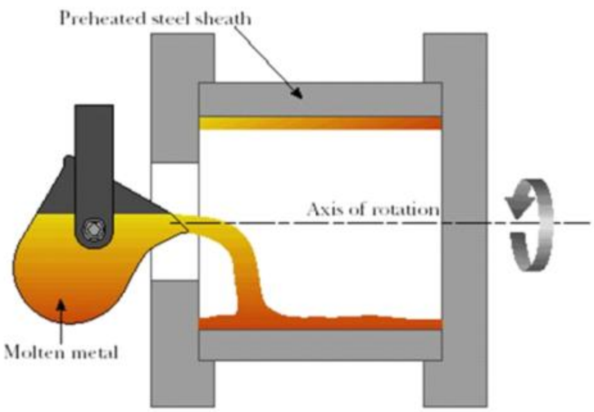


Figure P6.12

9. [SerPOP4 3.P.027.] --/2 points

The astronaut orbiting the Earth in Figure P4.32 is preparing to dock with a Westar VI satellite. The satellite is in a circular orbit 500 km above the Earth's

surface, where the free-fall acceleration is 8.14 m/s^2. Take the radius of the Earth as 6400 km.

Determine the speed of the satellite.
m/s
Determine the time interval required to complete one orbit around the Earth.
min

Figure P4.32

10. [SerPOP4 3.P.028.AF.] --/7 points

A point on a rotating turntable 22.5 cm from the center accelerates from rest to a final speed of 0.710 m/s in 1.85 s. At t = 1.27 s, find the magnitude and direction of each of the following.

(a) the radial acceleration

m/s^2

- toward the center
- away from the center
- in the direction of the rotation
- in a direction opposite to the rotation

(b) the tangential acceleration

m/s^2

- toward the center
- away from the center
- in the direction of the rotation
- in a direction opposite to the rotation

(c) the total acceleration of the point

m/s^2

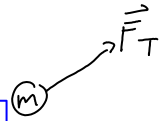
° ---Select---

Hint: Active Figure 3.12

Notes 10/22

Wednesday, October 22, 2008
10:57 AM

Laws of Motion Chapter 4 & 5

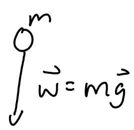


$$\boxed{\vec{a} = \left(\frac{1}{m}\right)\vec{F}_T}$$

N_{II}

$N_I : \vec{a} = 0$ if $\vec{F}_T = 0$

One Force



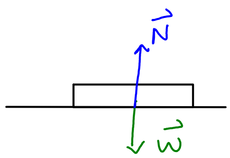
Free fall

Weight Force (N)

$$\vec{a} = \left(\frac{1}{m}\right)\vec{F}_T = \frac{1}{m} m\vec{g} = \vec{g}$$

so $\vec{a} = \vec{g} = -9.8\,m/sec^2$

Two Forces



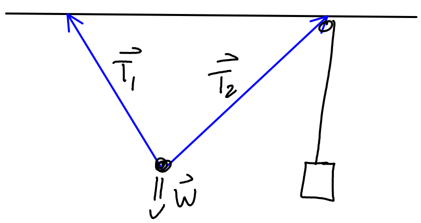
$\vec{N}$ = normal force

$\vec{F}_T = \vec{N} + \vec{W}$

$= 0$

Why?

Three forces



$\vec{T}_1 + \vec{T}_2 + \vec{W} = 0$

so $|\vec{T}_1| = |\vec{T}_2|$

Third Law

If objet A exists a force F_{AB} on object B then object B exerts a force F_{BA}

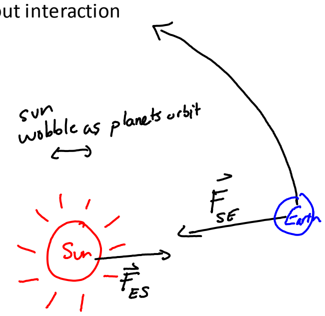
On object A

$F_{AB} = -F_{BA}$

*Forces never exist in isolation

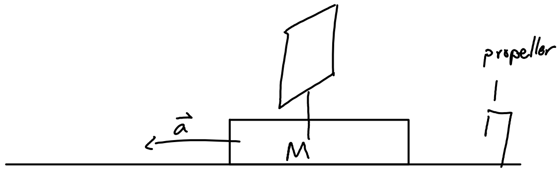
*Law about interaction

Example #1 NIII



$$\vec{F}_{ES} = -\vec{F}_{SE}$$

Example #2 NIII

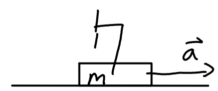


$$\vec{a} = \frac{\vec{F}_c}{M}$$

$\vec{F}_c$ = force on car

NIII: a force must be exerted on propeller

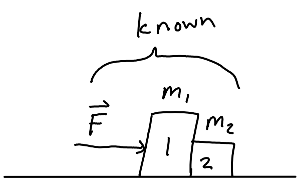
reaction force



$$\vec{F}_{SC} = m\vec{a}$$

Reaction force => propels ships, planes, and rockets

Example #8

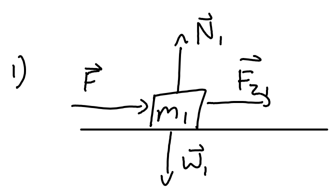


$\vec{F}$: Force exerted on N_1

$\vec{P}_{21}$ = force observed by 2 on 1?

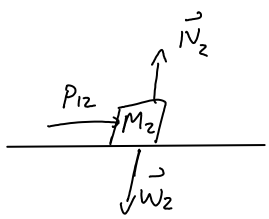
Steps:

1) Coordinate system
2) Free body force diagram



$$\vec{F}_{T1} = \vec{F} + \vec{P}_{21} + \vec{N} + \vec{W}$$

$$F_{T1} = \vec{F} + \vec{P}_{21}$$



$$\vec{F}_{T2} = \vec{P}_{12} + \vec{N}_2 + \vec{W}_2$$

$$F_{T2} = P_{12}$$

Step 3) $F = ma$

$$\vec{F}_{T1} = m_1 a_1$$

$$\boxed{F + P_{21} = m_1 a_1}$$

$$F_{T2} = m_2 a_2$$

$$\boxed{P_{12} = m_2 a_2}$$

relations: $a_1 = a_2$

$P_{21} = -P_{12}$

then solve stuff

Homework #4

Wednesday, October 22, 2008
3:42 PM

Web**Assign**

Homework Ch.4 (Homework)

HEATHER CATHERINE GRAEHL
Physics 6A, Fall 2008
Instructor: Robijn Bruinsma

Current Score: 0 out of 36
Due: Monday, October 27, 2008 11:59 PM PDT

1. [SerPOP4 4.P.041.AF.] --/2 points

An inventive child named Pat wants to reach an apple in a tree without climbing the tree. While sitting in a chair connected to a rope that passes over a frictionless pulley (Fig. P4.41). Pat pulls on the loose end of the rope with such a force that the spring scale reads 280 N. Pat's true weight is 230 N, and the chair weighs 160 N.

$mt = \frac{320+160}{9.8}$

A $\Sigma F = T_1 + T_2 - mg = ma$

$2T - mg = ma$

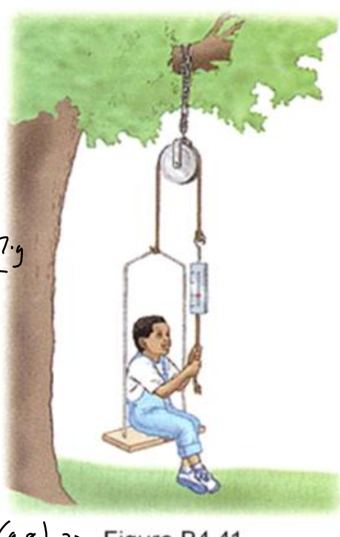
$a = \frac{2t - mg}{m} = \frac{2(330) - 48.97 \cdot g}{48}$

B) $a = 3.16$

c) $T - m_c g + N = ma$

$N = ma + m_c g - T$

$N = 16.32(3.75) - 16.32(9.8) - 330$
$= -119.88$



Pat + Chair

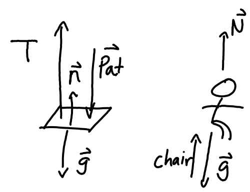


Figure P4.41

(a) Draw free-body diagrams for Pat and the chair considered as separate systems and another diagram for Pat and the chair considered as one system. (Do this on paper. Your instructor may ask you to turn in this work.)

390N 280N

m_1 m_2

$a = \left(\frac{m_2 - m_1}{m_1 + m_2}\right) g$

$a = \left(\frac{280 - 390}{390 + 280}\right) -9.8$

(b) Show that the acceleration of the system is *upward* (Do this on paper. Your instructor may ask you to turn in this work.) and find its magnitude.

1.61 m/s^2

(c) Find the force Pat exerts on the chair.

2254 N

Pat 230N

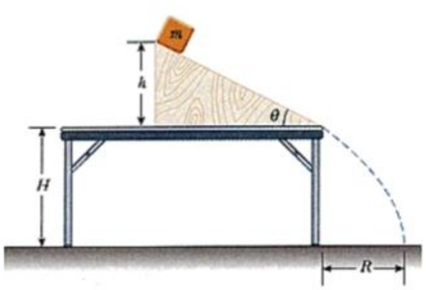
$\Sigma F_y = m\vec{a}$

$(230)(-9.8)$

Hint: Active Figure 4.12

2. [SerPOP4 4.P.044.] --/5 points

A block of mass m = 2.00 kg is released from rest at h = 0.300 m from the surface of a table, at the top of a θ = 35.0° incline as shown below. The frictionless incline is fixed on a table of height H = 2.00 m.



(a) Determine the acceleration of the block as it slides down the incline.

m/s^2

(b) What is the velocity of the block as it leaves the incline?

m/s

(c) How far from the table will the block hit the floor?

m

(d) How much time has elapsed between when the block is released and when it hits the floor?

s

(e) Does the mass of the block affect any of the above calculations?

Yes
No

3. [SerPOP4 4.P.040.] --/5 points

A 1040 kg car is pulling a 325 kg trailer. Together the car and trailer move forward with an acceleration of 2.18 m/s^2. Ignore any frictional force of air drag on the car and all frictional forces on the trailer. Determine the following.

(a) the net force on the car
N
(b) the net force on the trailer
N
(c) the force exerted by the trailer on the car
N
(d) the resultant force exerted by the car on the road
magnitude N
direction ° (measured from the left of vertically downwards)

4. [SerPOP4 4.P.024.] --/6 points

Figure P4.24 shows loads hanging from the ceiling of an elevator that is moving at constant velocity. Find the tension in each of the three strands of cord supporting each load, given that θ_1 = 40°, θ_2 = 50°, θ_3 = 56°, m_1 = 4 kg, and m_2 = 7 kg.

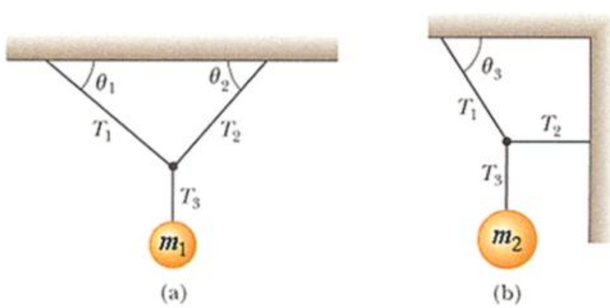


Figure P4.24

Figure (a) Figure (b)
T_1 = N T_1 = N

T_2 = N T_2 = N

T_3 = N T_3 = N

5. [SerPOP4 4.P.020.] --/2 points

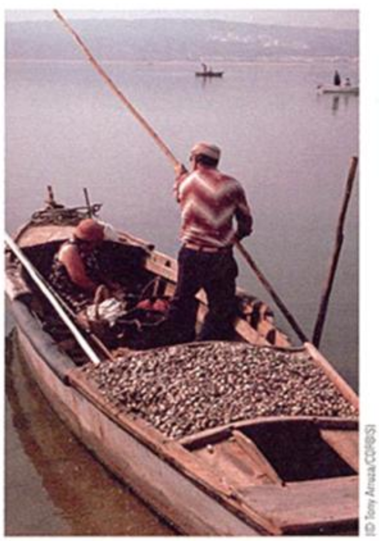
Figure P4.20 shows a worker poling a boat-a very efficient mode of transportation-across a shallow lake. He pushes parallel to the length of the light pole, exerting on the bottom of the lake a force of 250 N. The pole lies in the vertical plane containing the keel of the boat. At one moment the pole makes an angle of 35.0° with the vertical and the water exerts a horizontal drag force of 50.0 N on the boat, opposite to its forward motion at 0.857 m/s. The mass of the boat including its cargo and the worker is 370 kg.

$\Sigma F_x = P \sin\theta - d = m a$

$\Sigma F_y = p\cos\theta - Mg + B = 0$

$B =$

$B = (370)(9.8)$



p = pole = 250

Figure P4.20

(a) The water exerts a buoyant force vertically upward on the boat. Find the magnitude of this force.

N

$250 \cos 35°$

$B = mg - p\cos\theta$

(b) Model the forces as constant over a short interval of time to find the

$v(t) = v_1 + \left(\frac{p\sin\theta - D}{m}\right)t$

velocity of the boat 0.450 s after the moment described. (Take the forward direction to be positive.)

$\hat{\mathbf{i}}$ m/s

6. [SerPOP4 4.P.016.] --/2 points

The average speed of a nitrogen molecule in air is about 6.70×10^{2} m/s, and its mass is about 4.68×10^{-26} kg.

(a) If it takes 2.50×10^{-13} s for a nitrogen molecule to hit a wall and rebound with the same speed but moving in an opposite direction (assumed to be the negative direction), what is the average acceleration of the molecule during this time interval?

m/s^2

(b) What average force does the molecule exert on the wall?

N

7. [SerPOP4 4.P.013.] --/2 points

An electron of mass 9.11×10^{-31} kg has an initial speed of 3.00×10^{5} m/s. It travels in a straight line, and its speed increases to 8.00×10^{5} m/s in a distance of 4.00 cm.

(a) Assuming its acceleration is constant, determine the force exerted on the electron.

N (in the direction of motion)

(b) What is the ratio of this force to the weight of the electron, which we neglected?

8. [SerPOP4 4.P.012.] --/3 points

The gravitational force on a baseball is $-F_g\hat{\mathbf{j}}$. A pitcher throws the baseball with velocity $v\hat{\mathbf{i}}$ by uniformly accelerating it straight forward horizontally for a time interval $\Delta t = t - 0 = t$. If the ball starts from rest, determine the following: (Use Fg for F_g and v, g, and t as appropriate for each answer box.)

(a) Through what distance does it accelerate before its release?

(b) What force does the pitcher exert on the ball?

$\hat{i}$ + $\hat{j}$

9. **[SerPOP4 4.P.014.] --/2 points**

Besides its weight, a 4.20 kg object is subjected to one other constant force. The object starts from rest and in 1.20 s experiences a displacement of ($4.80\hat{i} - 3.30\hat{j}$) m, where the direction of $\hat{j}$ is the upward vertical direction. Determine the other force.

($\hat{i}$ + $\hat{j}$) N

10. **[SerPOP4 4.P.004.] --/7 points**

Two forces, $\vec{F}_1 = (-4\ \hat{i} - 4\ \hat{j})$ N and $\vec{F}_2 = (-5\ \hat{i} + 4\ \hat{j})$ N, act on a particle of mass 1.70 kg that is initially at rest at coordinates (+1.65 m, +4.40 m).

(a) What are the components of the particle's velocity at t = 9.8 s?

($\hat{i}$ + $\hat{j}$) m/s

(b) In what direction is the particle moving at t = 9.8 s?

° (counterclockwise from the positive x axis)

(c) What displacement does the particle undergo during the first 9.8 s?

($\hat{i}$ + $\hat{j}$) m

(d) What are the coordinates of the particle at t = 9.8 s?

x = m

y = m

Notes 10/24

Friday, October 24, 2008
11:11 AM

Laws of Motion

NI + NII $\quad \vec{a} = \frac{1}{m}\vec{F}_T$

$m = M$

$f = F$

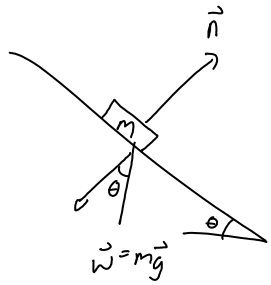
NIII) ① ⟶ ⟵ ②

$\vec{F}_{21} \qquad \vec{F}_{12}$

$\vec{F}_{12} = -\vec{F}_{21}$

Apply

FBFD



$W = w_x\hat{i} + w_y\hat{j}$

$w_x = Mg\sin\theta$

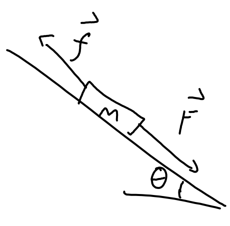
$w_y = -Mg\cos\theta$

$N_y + W_y = 0$

$F_T = \vec{W} + \vec{N} \neq 0$

$F_T = Mg\sin\theta\hat{i} + \underbrace{?}_{\text{static friction}}$

Static force is a cumulative effect of lots of interactions



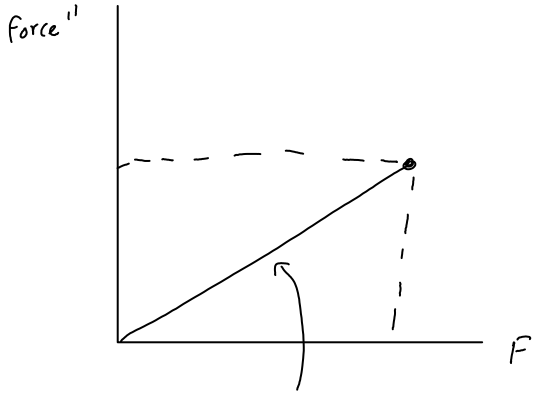
$F_x = Mg\sin\theta$

$\vec{F}_T = \vec{W} + \vec{N} + \vec{f} = 0$

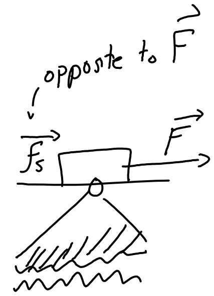
"friction force" f_s ⟵ depends on weight

opposite to $\vec{F}$

$\vec{F}$

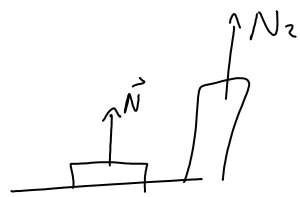


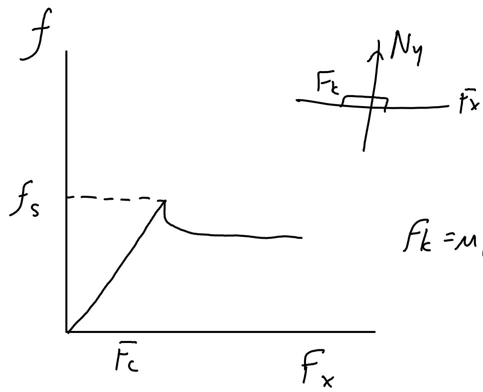
exp: $f_s = F$



max friction force: $f_s = \mu_s N$

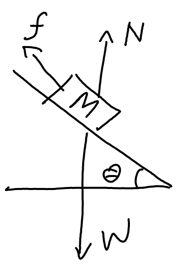
depends on interface





$f_k = \mu_k N$

Block of mass M on an plane included as an angle. What is the critical where the block slides? Given M,u_s, u_k



$N_y + W_y = 0$

$f + W_x = ma_x$

As $\theta = \theta_c$ where motion starts

$f = \mu_s N$

$-\mu_s N + Mg \sin\theta = 0$ ← $a_x = 0$ no motion

$N_y = W_y = 0$

$N_y = Mg\cos\theta$

$-\mu_s \cancel{Mg} \cos\theta_c + \cancel{Mg} \sin\theta_c = 0$

$-\mu_s \cancel{M} g \cos\theta_c + \cancel{M} g \sin\theta_c = 0$

as $\theta = \theta_c$

$\mu_s \cos\theta_c = \sin\theta_c$

$\mu_s = \tan\theta_c$

Notes 10/27

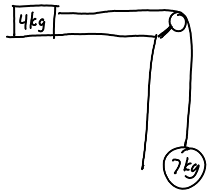
Monday, October 27, 2008
11:05 AM

Today: Ch 5: 5.1-5.3
Read: 5.5 and Ch 6

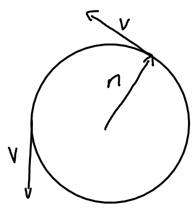
For $a \geq 0$

$$a = \left(\frac{m_2 - \mu_k m_1}{m_1 + m_2}\right) g$$

← In Serway



Uniform Circular Motion



v : speed (unknown)
r : radius

$$\vec{a} = \frac{d\vec{V}}{dt} \neq 0$$

magnitude of $\vec{a}$ $\quad a_c = \frac{v^2}{r}$

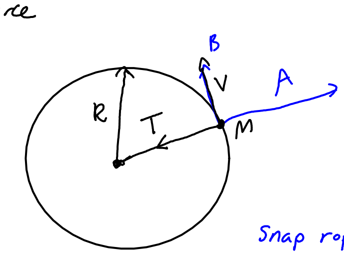
direction of $\vec{a}$: radial inward

NII: There must be a radial inward force

magnitude → $F_c = ma_c = \frac{mv^2}{r}$

F_c?

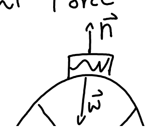
1) Tension force

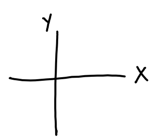


$$T = \frac{mv^2}{r}$$

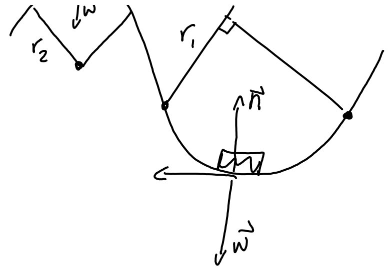
Snap rope then travel tangental V

2) Normal Force





weight



Case ① $\underbrace{N_y - Mg}_{\text{radial inward}} = \frac{Mv^2}{r_1}$

$N_y = M\left(g + \frac{v^2}{r_1}\right)$ big $\frac{v^2}{r_1}$ feel heavier

what is n?

Case ② $F_y = \underbrace{N_y - Mg}_{\text{radial outward}}$

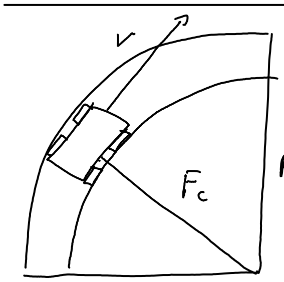
$-F_y = \frac{Mv^2}{r_2} = -N_y + Mg$

$\frac{Mv^2}{r^2} = Mg - N_y$

$N_y = M\left(g - \frac{v^2}{r_2}\right)$ big $\frac{v^2}{r_2}$ feel weightless

---

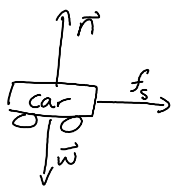
3)



$F_c = M\frac{v^2}{R}$

R = curvature radius

Friction keeps car on track
Rubber/Road



f is static friction b/c no radial displacement

$f_s \le \mu_s N = \mu_s Mg$

Static friction provide a force up $\mu_s Mg$

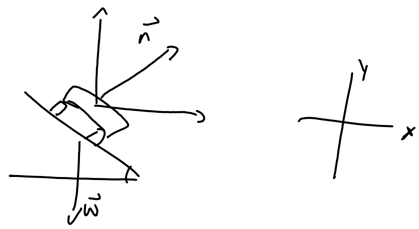
$$\frac{\cancel{M}v^2}{R} \le \mu_s \cancel{M}g$$

$$v \le \sqrt{\mu_s g R}$$

for $R = 35m$ & $\mu_s = 0.5$
$V_{max} = 13.4 m/s \sim 30 mi/hr$

faster 30mi/hr then kinetic friction and slides.
wet road then μ_s is less

bend road



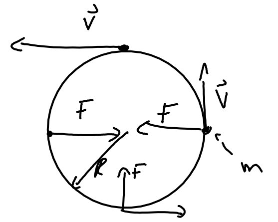
Notes 10/29

Wednesday, October 29, 2008
11:05 AM

Uniform Circular Motion

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

$F_c = \frac{mv^2}{R}$

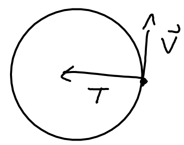


constant speed v

period T

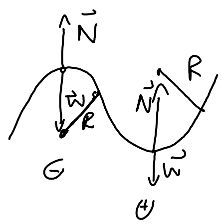
$\frac{2\pi R}{V} = T$

1) Tension $T = mv^2/R$

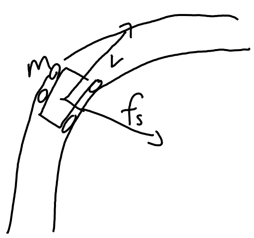


2) Normal force / weightless

$N - W = \pm \frac{mv^2}{R}$



3)



Friction

$f_s = \frac{mv^2}{R}$

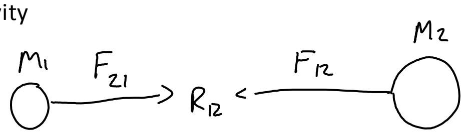
$f_s \leq \mu_s N$

$N = mg$

$V \leq \sqrt{\mu_s g R}$

maximum velocity, no slip

Force of gravity



$F_{12} = -F_{21}$

*attractive force $1 \leftrightarrow 2$
*magnitude

$$F_{12} \; g\frac{M_1 M_2}{R_{12}^2}$$

SI unit of g

$$\frac{N \times M^2}{kg^2} =$$

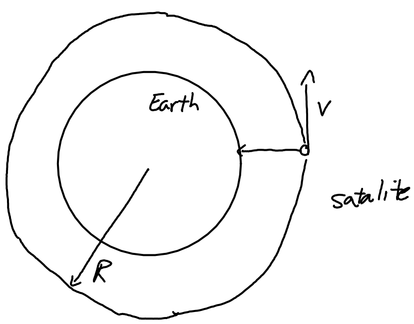
$$g = 6.67 \times 10^{-11} \frac{Nm^2}{kg}$$

"Inverse Square Law"

$R_{12} \longrightarrow 2R_{12}$

$F_{12} \longrightarrow \frac{1}{4} F_{12}$

GPS



$R = R_E + H$

$= 6{,}300 km + H$

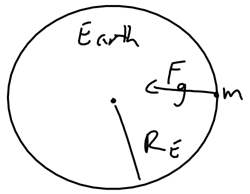
$$F_g = \frac{\cancel{m} v^2}{R} = \frac{g \cancel{m} M_E}{R_2}$$

$$v^2 = \frac{g M_e}{R}$$

$$v = \sqrt{\frac{g M_E}{R}}$$

$v \sim 73 \times 10^3 m/sec \sim 5 \text{ hours}$

$H \sim 1{,}000 km$

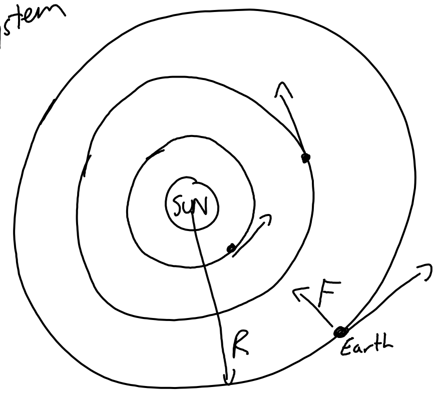


9.8m/sec²

$$F_g = \left(\frac{gM_E}{R_E^2}\right) m$$

weight force!

Solar system



$$F_g = \frac{gM_{SUN} \times m}{R^2}$$

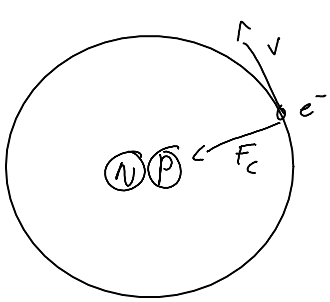
mass planet

$$v = \sqrt{\frac{gM_s}{R}} = \frac{2\pi R}{T}$$

square

$$\frac{gM_s}{R} = \frac{4\pi R^2}{T^2} = T^2 = \left(\frac{4\pi^2}{gM_s}\right) R^3$$

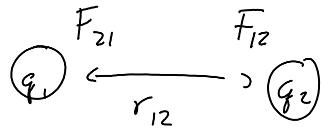
H atom



$$F_c = \frac{m_e v^2}{r}$$

$r \approx 10^{-10}$ m

Angstrom



$q_1\, q_2$ = 2 electrical charges opposite sign

magnitude $F_{12} = k_e \dfrac{q_1 q_2}{r_{12}^2}$

* attractive force $1 \longleftrightarrow 2$
* magnitude $F_{12} = g \dfrac{M_1 M_2}{R_{12}^2}$

* inverse square law
* k_e constant

k_e units $\dfrac{N \times m^2}{c^2}$

charge is measured in coulombs "c"

$k_e = 9 \times 10^9\ Nm^2/c^2$

* elementary charge

$e = 1.6 \times 10^{-19}\ C$

$\boxed{m_e \dfrac{v^2}{R} = k_e \dfrac{e^2}{r^2}}$ electrical force

$\boxed{\cancel{m} \dfrac{v^2}{R} = g \cancel{m} \dfrac{M_E}{R^2}}$ gravity

Notes 10/31

Friday, October 31, 2008
10:57 AM

Energy

- Different forms: rules of "energy exchange"

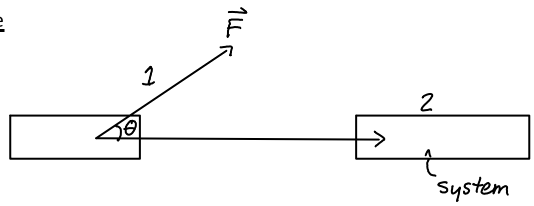
Work

W_{AB}

- Identify system
- Identify interaction of system Y with environment
- The work W_{AB} done by force F on system Y

$AO \longrightarrow OB$

Constant Force

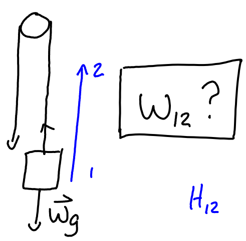


$W_{12} = F r_{12} \cos\theta$

*work no direction

$\Rightarrow$ scalar (mass, temp)

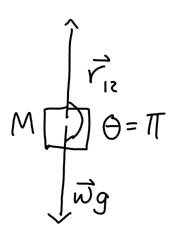
Example 1:



$\vec{T} + \vec{W}_g = 0$

Two possibilities

work done by force gravity on system M
as you raise M from 1→2

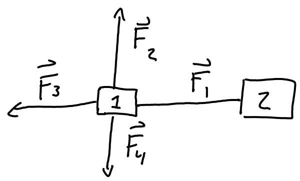


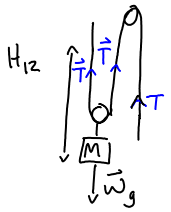
$W_g = (1 \to 2) = Mg \times H_{12} \times \cos\pi$

$W_g = -MgH_{12}$

Work done^{W_T} by you on system M raise by H_{12}

$W_T = M g H_{12}$





work done by T

$2\vec{T} + \vec{W}_g = 0$

$\vec{T} = \frac{Mg}{2}$

$\boxed{T < \text{less!}}$

$W_T = T \times H_{12} \times \cos\theta = 0$ ($\cos\theta$ = 1)

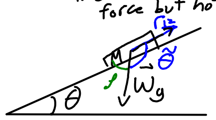
$? = \frac{1}{2} M g H_{12}$ → no must pull $2H_{12}$ distance on pully to lift by same amount

✓ $= M g H_{12}$

work is same, distance ×2, T is less

- Example. Constant force

there is friction and normal force but hot important with work done by gravity



* system M
* force of gravity W_g

$W_{12} = M g r_{12} \cos(\theta)$ ← angle between $\vec{W}_g$ & $\vec{r}_{12}$

$\theta + \varphi + \pi/2 = \pi$

$\varphi + \tilde{\theta} = \pi$

$\tilde{\theta} = (\theta + \frac{\pi}{2})$

$W_{12} = M g r_{12} \cos(\theta + \frac{\pi}{2})$

$\boxed{\text{Appendix } B_4 \to \text{know this trig}}$

Math Intermezzo

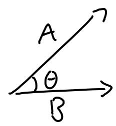
Math Intermezzo

Vector addition & subtraction

$\vec{A} \pm \vec{B}$

Vector Multiplication

$\vec{A} \cdot \vec{B}$



$\vec{A} \cdot \vec{B} = |A||B| \cos\theta$

scalar product or dot product

$W_{12} = \vec{F} \cdot \vec{r}_{12}$

$\hat{i} \cdot \hat{i} = 1 \times 1 \cos\theta$
$= 1$

$\hat{j} \cdot \hat{j} = 1$

$\hat{i} \cdot \hat{j} = 1 \times 1 \times \cos\frac{\pi}{2} = 0$

$\vec{A} = A_x \hat{i} + A_y \hat{j}$

$\vec{B} = B_x \hat{i} + B_y \hat{j}$

$\vec{A} \cdot \vec{B} = (A_x \hat{i} + A_y \hat{j}) \cdot (B_x \hat{i} + B_y \hat{j})$

$A_x B_x \hat{i} + A_y B_y \hat{j}$

$\vec{A} \cdot \vec{B} = A_x B_x + A_y B_y$

$\vec{A} \cdot \vec{A} = A_x^2 + A_y^2 = A^2$

$\vec{A} = (2,3)$

$\vec{B} = (-1,2)$

angle θ between

$|\vec{A}| = \sqrt{13}$

$|\vec{B}| = \sqrt{5}$

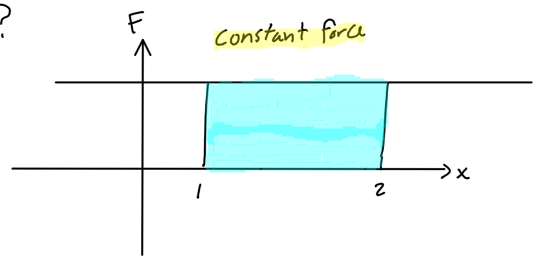
$-2 + 6 = \sqrt{13 \times 5} \cos\theta$

$4 = \sqrt{65} \cos\theta$

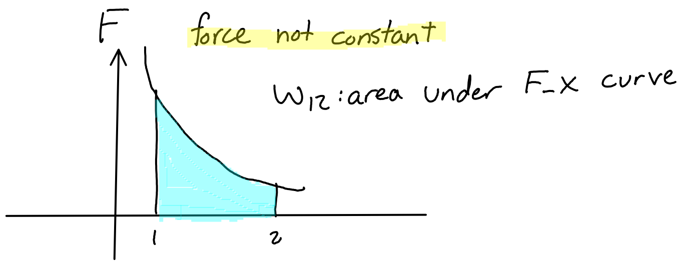
$\cos\theta = \frac{4}{\sqrt{65}}$

Force is not constant:

Work?



$W_{12} = F x_{12}$
= area under
F_x curve



Area $\int_a^b dx f(x)$

$\boxed{\text{Read B 6 \& 7}}$

$W_{12} = \int_{x_1}^{x_2} F(x)dx$

Homework #5

Saturday, November 01, 2008
6:42 PM

WebAssign

Homework Ch.5/11.1 (Homework)

HEATHER CATHERINE GRAEHL
Physics 6A, Fall 2008
Instructor: Robijn Bruinsma

Current Score: 0 out of 16
Due: Monday, November 3, 2008 11:59 PM PST

1. [SerPOP4 5.P.002.] --/2 points

A car is traveling at 48.0 mi/h on a horizontal highway.

(a) If the coefficient of static friction between road and tires on a rainy day is 0.105, what is the minimum distance in which the car will stop?
m

(b) What is the stopping distance when the surface is dry and μ_s = 0.601?
m

2. [SerPOP4 5.P.004.] --/2 points

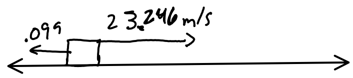
The person in Figure P5.4 weighs 180 lb. As seen from the front, the crutches each make an angle of 20.0° with the vertical. Half of the person's weight is supported by the crutches. The other half is supported by the vertical forces of the ground on the person's feet.

Figure P5.4

(a) Assuming that the person is moving at constant velocity and the force exerted by the ground on the crutches acts along the crutches, determine the smallest possible coefficient of friction between crutches and ground.

A car is traveling at 52.0 mi/h on a horizontal highway.
(a) If the coefficient of static friction between road and tires on a rainy day is 0.099, what is the minimum distance in which the car will stop?
m

(b) What is the stopping distance when the surface is dry and μ_s = 0.595?



(b) Determine the magnitude of the compression force supported by each crutch.

lb

3. [SerPOP4 5.P.015.] --/1 points

A light string can support a stationary hanging load of 27.0 kg before breaking. A 3.00 kg object attached to the string rotates on a horizontal, frictionless table in a circle of radius 0.800 m, while the other end of the string is held fixed. What range of speeds can the object have before the string breaks?

$0 < v <$ m/s

4. [SerPOP4 5.P.016.] --/2 points

In the Bohr model of the hydrogen atom, the speed of the electron is approximately 1.90×10^6 m/s.

(a) Find the force acting on the electron as it revolves in a circular orbit of radius 5.30×10^{-11} m

N

(b) Find the centripetal acceleration of the electron.

m/s^2

5. [SerPOP4 5.P.017.] --/1 points

A crate of eggs is located in the middle of the flat bed of a pickup truck as the truck negotiates an unbanked curve in the road. The curve may be regarded as an arc of a circle of radius 32.5 m. If the coefficient of static friction between crate and truck is 0.580, how fast can the truck be moving without the crate sliding?

m/s

6. [SerPOP4 5.P.019.AF.] --/3 points

Consider a conical pendulum with an 81.0 kg bob on a 10.0 m wire making an angle of $\theta = 7.00°$ with the vertical (Fig. P5.19).

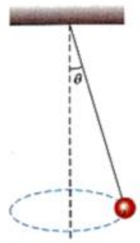


Figure P5.19

(a) Determine the horizontal and vertical components of the force exerted by the wire on the pendulum.

N $\hat{i}$ + N $\hat{j}$

(b) What is the radial acceleration of the bob?

m/s^2 (toward the center of the path)

Hint: Active Figure 5.15

7. [SerPOP4 5.P.031.soln.] --/1 points

Two identical isolated particles, each of mass 1.65 kg, are separated by a distance of 29.1 cm. What is the magnitude of the gravitational force exerted by one particle on the other?

N

8. [SerPOP4 11.P.013.] --/2 points

A communication satellite in geosynchronous orbit remains above a single point on the Earth's equator as the planet rotates on its axis.

(a) Calculate the radius of its orbit.

m

(b) The satellite relays a radio signal from a transmitter near the North Pole to a receiver, also near the North Pole. Traveling at the speed of light, how long is the radio wave in transit?

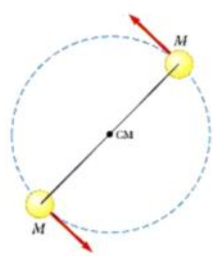
s

9. [SerPOP4 11.P.015.] --/1 points

Io, a satellite of Jupiter, has an orbital period of 1.77 days and an orbital radius of 4.22×10^5 km. From these data, determine the mass of Jupiter.
kg

10. [SerPOP4 11.P.017.] --/1 points

Plaskett's binary system consists of two stars that revolve in a circular orbit about a center of mass midway between them. This means that the masses of the two stars are equal. Assume the orbital speed of each star is 195 km/s and the orbital period of each is 12.4 days. Find the mass M of each star. (For comparison, the mass of our Sun is 1.99×10^{30} kg.)
solar masses



Notes 11/03

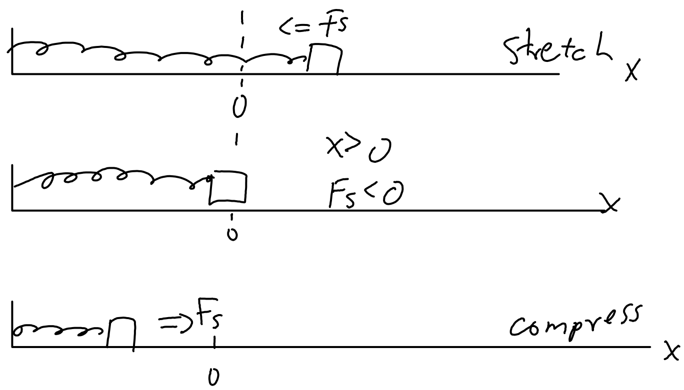
Monday, November 03, 2008
11:02 AM

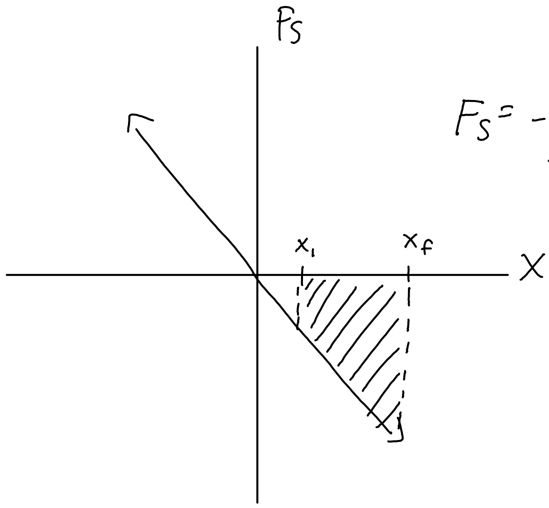
Work

Work "scalar" unit Joule (J)
By a force F on system Y

Force constant

W=Fr_{12}cos(theta)





$$F_S = -kx$$

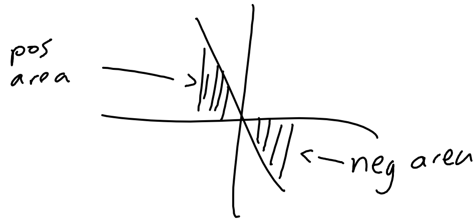
spring constant (units N/m)

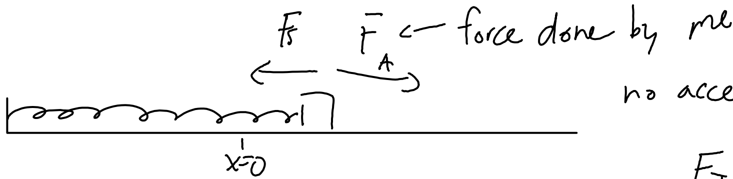
$$A = \frac{1}{2}\int k x_f^2 - k x_i^2$$

work

Work by spring on stretching must be negative

$$W = \int_{x_1}^{x_f} F_s dx = -k \int_{x_1}^{x_f} x dx$$





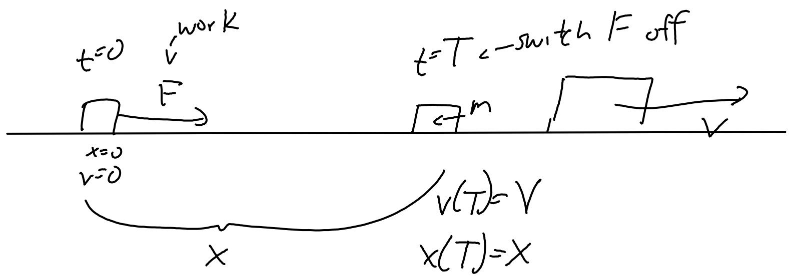
no acceleration $a=0$

$F_T = A_A + F_S = 0$

$F_A = -F_S$

work done by spring ⟶ $W_S =$

$W_A = -W_S$



$$W_F = FX$$

$$x(t) = \underbrace{x_i}_{0} + \underbrace{v_i}_{0} t + \frac{1}{2}\underbrace{a}_{F/M} t^2 = \frac{1}{2}\left(\frac{F}{m}\right)t^2$$

$$v(t) = at = \left(\frac{F}{m}\right)t$$

eliminate t

$$\boxed{W_F} = FX = \cancel{F}\frac{1}{2}\left(\frac{\cancel{F}}{m}\right)\left(\frac{mV}{\cancel{F}}\right)^2 = \boxed{\frac{1}{2}mV^2}$$

<u>Kinetic Energy</u>

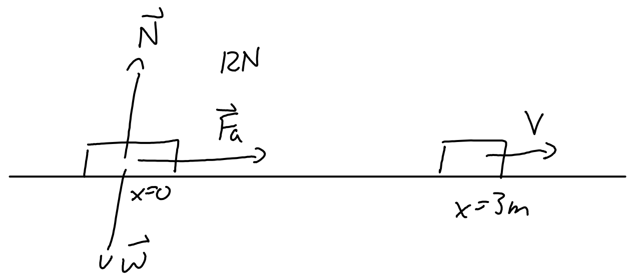
$$K = \frac{1}{2}mV^2$$

Work-kinetic energy theory: when work is done on a system and the only result is a change in velocity then the work done is the change in kinetic energy.

$$W_F = K_f - K_i$$

$W_{if} > 0$: energy transferred to system

$W_{if} < 0$: energy transferred from system



$$W_{if} = K_f - K_i = \frac{1}{2} m V^2$$

work on system

$$W_{if} = \underset{12N}{F_A} \times \underset{3M}{\Delta x} = 36J$$

Notes 11/06

Wednesday, November 05, 2008
11:05 AM

Midterm II Review

Franz Hall 1187 Monday 5pm

Ch 4-6 (didn't cover fluid/drag in chap 5), 11.1 gravity

Energy

Kinetic energy

$K=1/2MV^2$

"energy by virtue of motion"

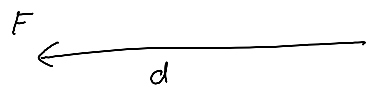
$W_{if}=K_f-K_i$

*only effect of work W_{if} change V from V_i to V_f

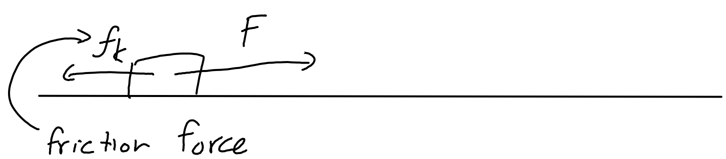
Example

$$Fd = \frac{1}{2}M(v_f^2 - v_i^2)$$

only constant force



*only true if no friction



*add work done by friction force

$$W_f = -f_k d \qquad f_k = \mu_k n$$

$$W_{if} = W_F + W_f = K_f - K_i$$

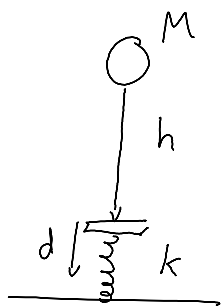
$$W_F = -W_f + K_f - K_i$$

$$\boxed{W_F = f_k d + K_f - K_i}$$

extra work due to friction

Serway problem

Draop a ball on spring



what is max compression, d, of spring

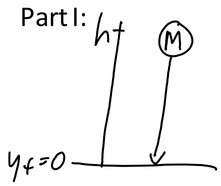
$v_i = 0$ so $K_i = 0$

$v_f = 0$ so $K_f = 0$

Using work energy theorem

Break up problem into 2 parts. One before ball hits spring (h) and one during spring compression (d)

Part I:



$y_i = h$

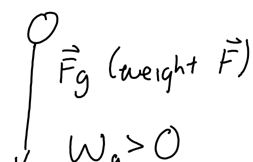
$K_i = 0$

$y_f = 0$

$K_f = \frac{1}{2}mv^2$

work is done by gravity

$W_g = \pm Mgh$



$W_g > 0$

work

Work Energy theorem

$\boxed{\text{Part I: } W_g = \frac{1}{2}Mv^2 = Mgh}$

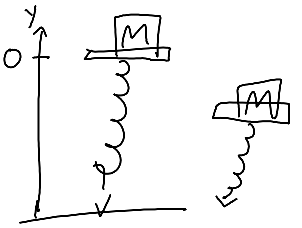
now know velocity that ball strikes spring.

Part II

Part II

$y_i = 0$

$K_i = Mgh$



$y_f = -d$

$K_f = 0$

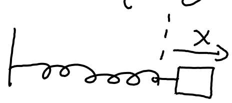
2 forces spring does negative work $W_s < 0$

gravity does + work $W_g > 0$

$$W_{if} = W_g + W_s$$

$$W_g = Mgd$$

$$W_s = \frac{1}{2}kx_i^2 - \frac{1}{2}kx_f^2$$

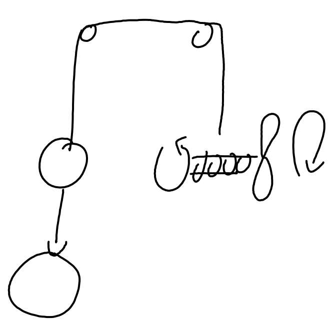


by spring on M

$$W_s = -\frac{1}{2}kd^2$$

$$W_{if} = \frac{1}{2}MV^2 = Mgh$$

$$Mgd - \frac{1}{2}kd^2 = Mgh$$



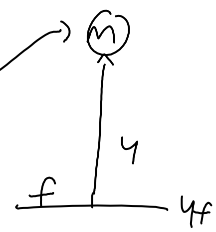
Potential Energy U

"energy stored by virtue of the position of a system"
Energy storage

$W_{i\to f} = U_i - U_f$

1. Gravitational positional energy

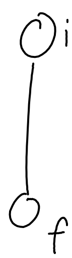
$U_g = Mgy$



U_1 $\quad$ U_f

$W_{i\to f} = Mg\times(y_i - y_f)$

$U_1 = mg^{k}$
$K_i = 0$



$k =$

$\xrightarrow{U_f = 0}$ $K_f = \frac{1}{2}MV^2$

$\frac{1}{2}MV^2$

$\boxed{\text{U + K = constant (sum of kinetic and potential energy is constant)}}$

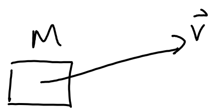
E = K + U

E = mechanical energy
K = kinetic energy
U = potential energy

Notes 11/07

Friday, November 07, 2008
10:57 AM

Midterm Review
- Monday 5pm
  - Franz Hall 1178
- Tuesday 5-6pm
  - Knudsen hall main entrance 5pm



$K = \frac{1}{2} M v^2$ Kinetic Energy

Energy by virtue of motion

$K = \frac{1}{2} M V^2$

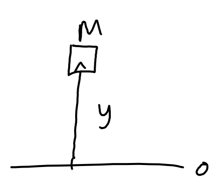
$W_f = K_f - K_i = \Delta K$

work done on system

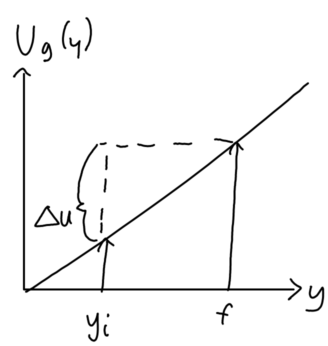
U Potential Energy

* Energy of a system by virtue of its location
* Energy is stored

1. "Gravitation Potential Energy"

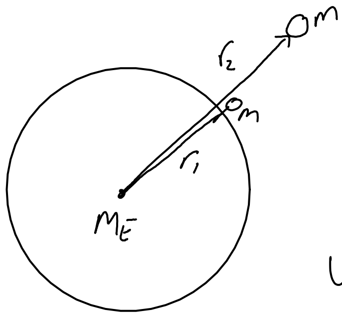


$U_g = Mgy$



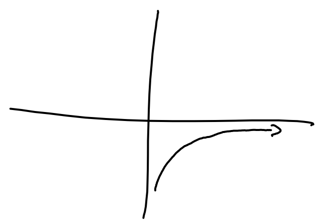
$\Delta U_g = U_{gf} - U_{gi}$

$$= \underbrace{Mg}_{\text{weight}}\underbrace{(y_f - y_i)}_{\Delta y} = W_{if}$$

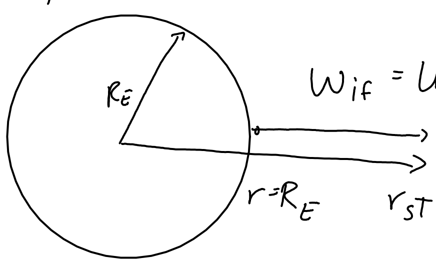


$$F_g = \frac{-gM_E m}{r^2}$$

$$U_g = -\frac{gM_E m}{r}$$

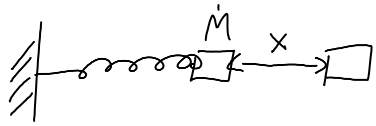


Ex: space elevator



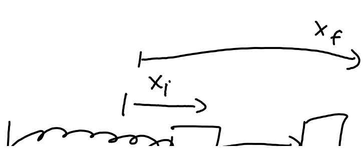
$$W_{if} = U_g(r_{ST}) - U_g(r=R_E)$$

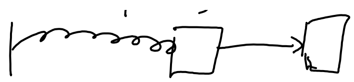
2. Potential Energy of a Harmonic Spring



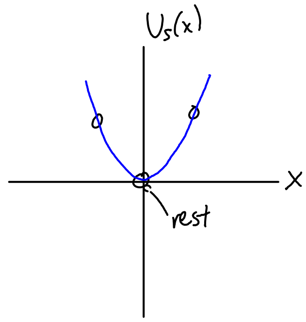
$$F_s(x) = -kx$$

energy in stretched or compressed spring $\rightarrow$ $\boxed{U_s(x) = \frac{1}{2}kx^2}$





$$W_{if} = U_s(x_f) - U_s(x_i) = \frac{1}{2}kx_f^2 - \frac{1}{2}kx_i^2$$
$$= \Delta U$$



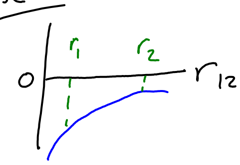
3. Electrical Potential Energy

q_1 ← r_{12} → q_2

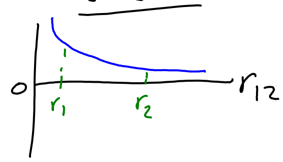
$$F_e = k_e \frac{q_1 q_2}{r_{12}^2} \quad \text{magnitude}$$

$$U_e = k_e \frac{q_1 q_2}{r_{12}}$$

case 1



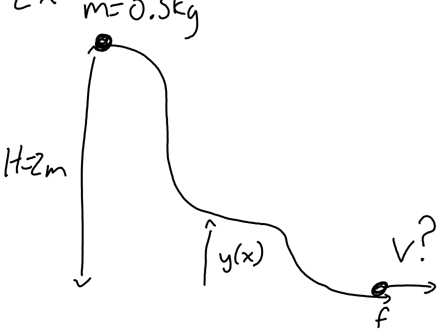
case 2



q_1 & q_2 have opposite sign

q_1 & q_2 have same sign

Ex



$\mathcal{E} = K + U$ <-- conserved

<u>initial state</u>

$K = 0, \quad U_g = MgH$

$K = \frac{1}{2}MV^2 \quad U_g = 0$

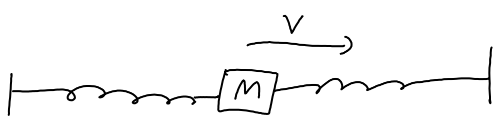
$\mathcal{E} = K + U = MgH$

$\mathcal{E} = \frac{1}{2}MV^2$

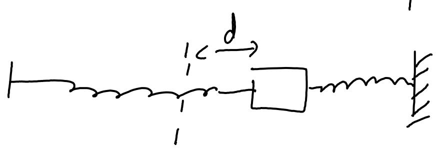
$\frac{1}{2}MV^2 = MgH$

$V^2 = 2gH$

$\boxed{V = (2gH)^{1/2}}$



what is max compression?



<u>Initial State</u>

$K = \frac{1}{2}MV^2 \quad U = 0$

$\mathcal{E} = K + U = \frac{1}{2}MV^2$

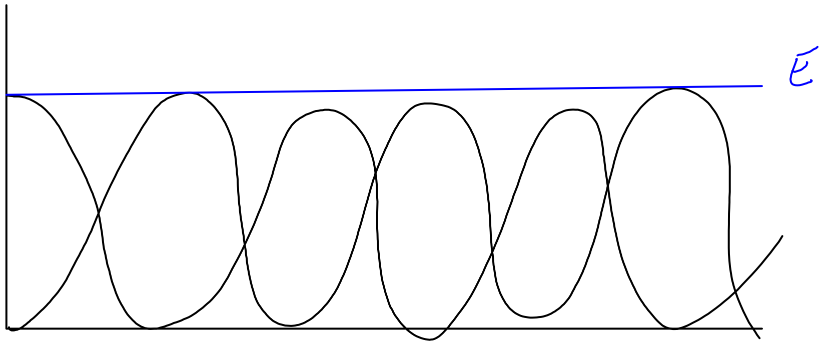
<u>Final State</u>

$K = 0 \quad U = \frac{1}{2}kd^2$

$\mathcal{E} = K + U + \frac{1}{2}kd^2$

$\frac{1}{2}MV^2 = \frac{1}{2}kd^2$

$$\boxed{d = \sqrt{\frac{MV^2}{k}}}$$



$E = K + U$

Homework #6

Sunday, November 09, 2008
2:26 PM

WebAssign

Homework Ch.6 (Homework)

HEATHER CATHERINE GRAEHL
Physics 6A, Fall 2008
Instructor: Robijn Bruinsma

Current Score: 0 out of 29
Due: Monday, November 10, 2008 11:59 PM PST

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1. [SerPOP4 6.P.001.] --/4 points

A block of mass 4.00 kg is pushed 2.60 m along a frictionless horizontal table by a constant 16.0 N force directed 23.0° below the horizontal.

(a) Determine the work done on the block by the applied force.
J

(b) Determine the work done on the block by the normal force exerted by the table.
J

(c) Determine the work done on the block by the gravitational force.
J

(d) Determine the total work done on the block.

J

2. [SerPOP4 6.P.004.soln.] --/2 points

A raindrop of mass 3.21 × 10^{-5} kg falls vertically at constant speed under the influence of gravity and air resistance. Model the drop as a particle.

(a) As it falls 120 m, what is the work done on the raindrop by the gravitational force?

J

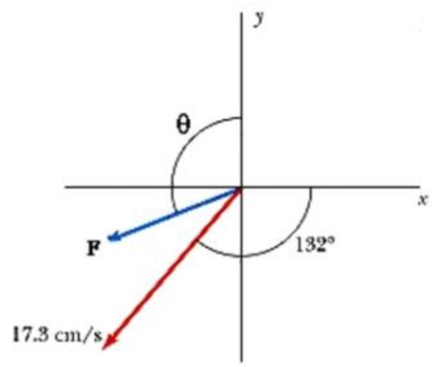
(b) What is the work done on the raindrop by air resistance?

J

3. [SerPOP4 6.P.005.] --/1 points

Find the scalar product of the vectors in the figure below, where θ = 121° and F = 32.5 N.

W



4. [SerPOP4 6.P.007.] --/2 points

A force $\vec{F} = (5\ \hat{i} - 3\ \hat{j})$ N acts on a particle that undergoes a displacement $\Delta\vec{r} = (2\ \hat{i} + \hat{j})$ m.

(a) Find the work done by the force on the particle. (Calculate all numerical answers to three significant figures.)

4.0 ✓ ________ J

(b) What is the angle between $\vec{F}$ and $\Delta\vec{r}$?

4.0 ✓ ________ °

5. [SerPOP4 6.P.009.] --/3 points

Using the definition of the scalar product, find the angles between the following pairs of vectors.

(a) $\vec{A} = -4\,\hat{i} + 3\,\hat{j} + 3\,\hat{k}$ and $\vec{B} = 5\,\hat{i} + \hat{j} - 3\,\hat{k}$

°

(b) $\vec{A} = 5\,\hat{i} - 4\,\hat{k}$ and $\vec{B} = -3\,\hat{i} - 3\,\hat{k}$

°

(c) $\vec{A} = 2\,\hat{i} + 4\,\hat{j} - \hat{k}$ and $\vec{B} = \hat{j} + 3\,\hat{k}$

°

6. [SerPOP4 6.P.011.AF.] --/4 points

A particle is subject to a force F_x that varies with position as in Figure P6.11.

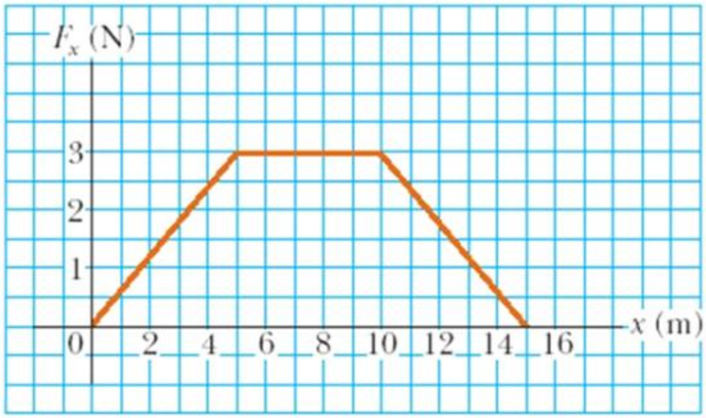


Figure P6.11

Find the work done by the particle on the body as it moves across the following distances.

(a) from x = 0 to x = 4.00 m

J

(b) from x = 5.00 m to x = 8.00 m

J

(c) from x = 13.0 m to x = 15.0 m

J

(d) What is the total work done by the force over the distance x = 0 to x = 15.0 m?

J

Hint: Active Figure 6.8

7. [SerPOP4 6.P.013.] --/2 points

When a 4.00 kg object is hung vertically on a certain light spring that obeys Hooke's law, the spring stretches 2.60 cm.

(a) If the 4.00 kg object is removed, how far will the spring stretch if a 1.50 kg block is hung on it?

cm

(b) How much work must an external agent do to stretch the same spring 4.00 cm from its unstretched position?

J

8. [SerPOP4 6.P.021.soln.] --/3 points

A 0.800 kg particle has a speed of 1.80 m/s at point *A* and kinetic energy of 7.30 J at point *B*.

(a) What is its kinetic energy at *A*?

J

(b) What is its speed at *B*?

m/s

(c) What is the total work done on the particle as it moves from *A* to *B*?

J

---

9. [SerPOP4 6.P.025.] --/1 points

A 1800 kg pile driver is used to drive a steel I-beam into the ground. The pile driver falls 7.00 m before coming into contact with the top of the beam, and it drives the beam 12.0 cm farther into the ground before coming to rest. Using energy considerations, calculate the average force the beam exerts on the pile driver while the pile driver is brought to rest.

N

---

10. [SerPOP4 6.P.028.] --/4 points

In the neck of the picture tube of a certain black-and-white television set, an electron gun contains two charged metalic plates 2.80 cm apart. An electric force accelerates each electron in the beam from rest to 7.50% of the speed of light over this distance. (Ignore the effects of relativity in your calculations.)

(a) Determine the kinetic energy of the electron as it leaves the electron gun. Electrons carry this energy to a phosphorescent material on the inner surface of the television screen, making it glow.

J

(b) For an electron passing between the plates in the electron gun, determine the magnitude of the constant electric force acting on the electron.

N

(c) Determine the electron's acceleration as it passes between the plates.

m/s^2

(d) Determine the time of flight as the electron passes between the plates.

s

11. [SerPOP4 6.P.038.] --/3 points

Energy is conventionally measured in Calories as well as in joules. One Calorie in nutrition is one kilocalorie, defined as 1 kcal = 4186 J. Metabolizing 1 g of fat can release 9.00 kcal. A student decides to try to lose weight by exercising. She plans to run up and down the stairs in a football stadium as fast as she can and as many times as necessary. Is this in itself a practical way to lose weight? To evaluate the program, suppose she runs up a flight of 80 steps, each 0.150 m high, in 72.0 s. For simplicity, ignore the energy she uses in coming down (which is small). Assume that a typical efficiency for human muscles is 20.0%. Therefore when your body converts 100 J from metabolizing fat, 20 J goes into doing mechanical work (here, climbing stairs). The remainder goes into extra internal energy. Assume that the student's mass is 66.0 kg.

(a) How many times must she run the flight of stairs to lose 1 lb of fat?

times

(b) What is her average power output, in watts and horsepower, as she is running up the stairs?

W

hp

Notes 11/10

Monday, November 10, 2008
11:01 AM

Chapter 4

Force F

Units N=kgm/sec

Force addiion: F_1 +/- F_2 vector addition

NI) If an object does not interact with other objects than a=0

$$\vec{F_1} = \Sigma F = 0$$

NII) If object interacts with other objects than $\vec{F_T} = \Sigma \vec{F} = ma$

$$\Sigma F_x = ma_x$$
$$\Sigma F_y = ma_y$$
$$\Sigma F_z = ma_z$$

m: inertial mass(kg)

$w = m\vec{g}$: weight force (N)

$\vec{g} = (0, -9.8\, m/sec)$

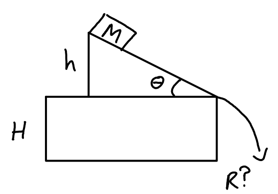
NIII) If 1 exerts a force F_{12} on 2 then 2 exerts a force F_{21}=-F_{12} on 1

$$① \xrightarrow{F_{21}} \text{———} \xleftarrow{F_{12}} ②$$

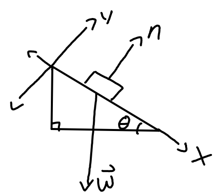
Types of Forces

Fundamental	Macroscopic
Gravity, electromagnetic, strong/weak interaction	Normal, tension, contact, spring, friction

---



Part 1



$$\Sigma \vec{F} = \vec{N} + \vec{W}$$

$$\Sigma F_x = ma_x$$
$$\Sigma F_y = ma_y = 0$$

$$N - mg\cos\theta = 0$$
$$\cancel{M}g\sin\theta = \cancel{M}a_x$$

Part II need v_0

a constant

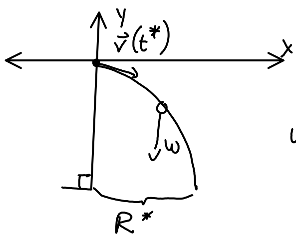
$x(t) = \cancel{x(0)} + \cancel{v(0)t} + \frac{1}{2}at^2$

$x(t) = \cancel{x(0)} + \cancel{v(0)}t + \frac{1}{2}at^2$

$v(t) = \cancel{v(0)} + at$

$L = \frac{h}{\sin\theta}$

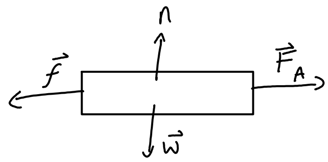
$t^* \quad x(t^*) = \frac{1}{2} g \sin\theta \, t^{*2} = h\sin\theta$



$w = mg$

Chapter 5

Friction f

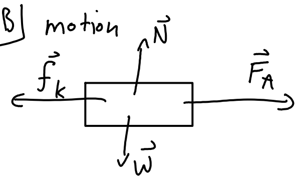


case $\boxed{A}$ no motion: $F_A \leq \mu_s N$ ← static friction coefficient

$f = F_A$

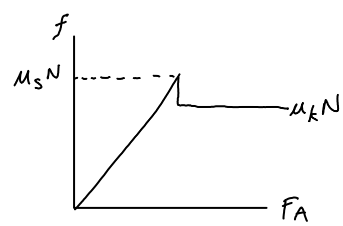
$\Sigma \vec{F} = 0$

Case $\boxed{B}$ motion

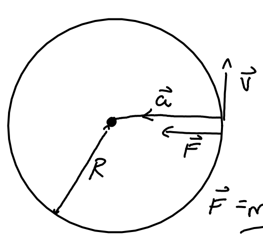


$f_k = \mu_k N$

$\Sigma \vec{F} \neq 0$



uniform circular motion

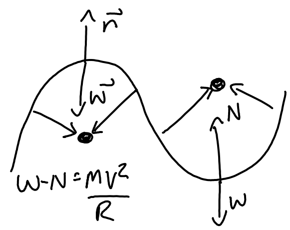


$V = \frac{2\pi R}{T}$ ← orbital period

$a = \frac{V^2}{R}$

$\vec{F} = \frac{mv^2}{R}$ ← inward radial force

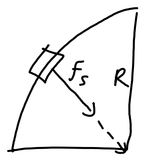
1) Tension
2) Weight + Normal force



$W - N = \frac{mv^2}{R}$ $N - W = \frac{mv^2}{R}$

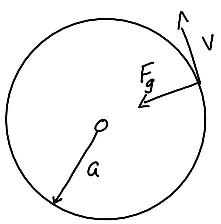
inward radial force diff depending if center of circle is inward or outward

3)



friction force
$f_s = \mu_s N$

4) Gravity

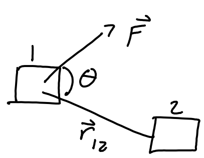


Ch 11.1 $\boxed{F_g = g\frac{M_1 M_2}{R_{12}^2}}$
universal law of gravity

$\boxed{T^2 = \left(\frac{4\pi^2}{gM_s}\right)a^3}$ kepler's 3rd law

Chapter 6: Energy

W = work
units J = Newton × Meter



constant force

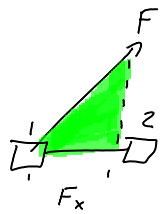
$W_{12} = F r_{12} \cos\theta$
scalar product of $\vec{F} \cdot \vec{r}_{12}$

force dir motion, pos Work
force opp dir. motion, neg work

$\vec{A} \cdot \vec{B} = AB\cos\theta$
$A_x B_x + A_y B_y$

not constant force

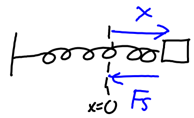
$W = \int_{x_1}^{x_2} F_x dx$



x direction

area under F_x vs x curve

Spring $F_s(x) = -kx$



$$W_s(x_1 \to x_2) = \frac{1}{2}kx_1^2 - \frac{1}{2}kx_2^2$$

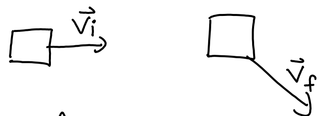
work done <u>by</u> spring

Energy of motion

$$K = \frac{1}{2}Mv^2$$

energy by virtue of motion

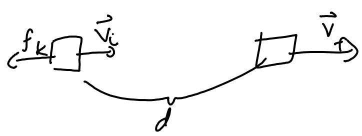
W_K Theorem



true if no friction

$$W = K_f - K_i$$

if friction



$$W_{if} = K_f - K_i + f_k d$$

Power delivered by a force F is work done per second by the force

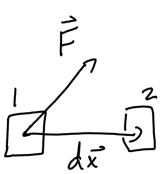
$$P_{AV} = \frac{\Delta W}{\Delta t}$$

time over which force works

units: Joule/sec = Watt = kg m²/sec³

$$P_{inst} = \frac{dW}{dt}$$

← work done by $\vec{F}$



$$dW = \vec{F} \cdot d\vec{x}$$

$$\text{Power} = \frac{dW}{dt} = \vec{F}\cdot\frac{d\vec{x}}{dt} = \boxed{\vec{F}\cdot\vec{v} = \text{Power delivered by F at t}}$$

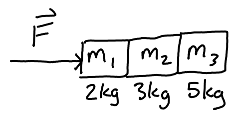
Practice MT 2

Tuesday, November 11, 2008
12:09 PM

Trial Midterm

Problem 1

Three blocks with masses m1, m2, and m3 are in contact with each other on a frictionless, horizontal surface. A horizontal force F is applied to m1. Take m1 = 2.00 kg, m2 = 3.00 kg, m3 = 5.00 kg, and F = 19.0 N.



(a) Draw a separate free-body diagram for each block.

(b) Find the acceleration of the blocks

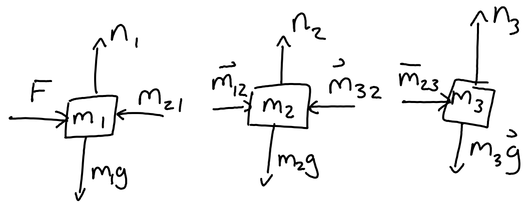
(c) Find the resultant force on each of the three blocks

(d) Find the magnitude of the *contact force* between m1 and m2 and between m2 and m3.

d $F_T = F - C_1 = m_1 a$

$C_1 = 19 - 2 \times 19 = 15N$

a



c

$F_T(1) = m_1 a$

$F_T(2) = m_2 a$

$F_T(3) = m_3 a$

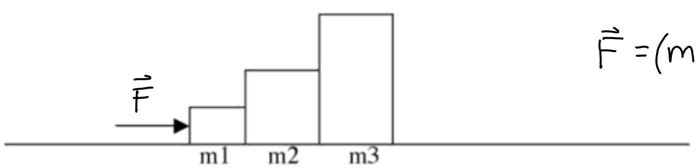
b

$a_{m_1} = a_{m_2} = a_{m_3}$

$\vec{F} = (m_1 + m_2 + m_3) a$

$a = \dfrac{F}{m_1 + m_2 + m_3}$

$a = \dfrac{19}{2+3+5} = 1.9\ m/s^2$



d

$\sum F_x = m_{12} = m_2 a$

$= m_{12} = m_2 \left(\dfrac{F}{m_1 + m_2 + m_3} \right)$

$m_{12} = (3)(1.9) = 5.7$

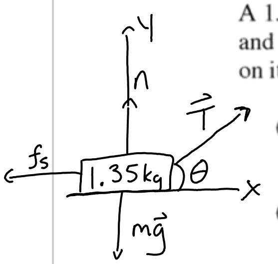
$m_{21} = -5.7$

$m_{23} = m_3 a = m_3 \left(\dfrac{F}{m_1 + m_2 + m_3} \right) = 9.5$

$m_{32} = -9.5$

18°, 4N

Problem 2



$mg = 13.23$

A 1.35 kg toaster is not plugged in. The coefficient of static friction between the toaster and a horizontal countertop is 0.325. To make the toaster start moving you carelessly pull on its electric cord. $\mu_s = 0.325$

(a) For the cord tension to be as small as possible, you should pull at what angle above the horizontal? $f_s = \mu_s n = (.325)(-13.23) = 4.29975$

(b) With this angle, how large must the tension be?

Problem 3:

A 4.20 kg steel ball is dropped onto a copper plate from a height of 10.0 m. If the ball leaves a dent 3.60 mm deep, what is the average force exerted by the plate on the ball during the impact?

Problem 4:

Io, a satellite of Jupiter, has an orbital period of 1.77 days and an orbital radius of 4.22 multiplied by 105 km. From these data, determine the mass of Jupiter.

Keplar's Law

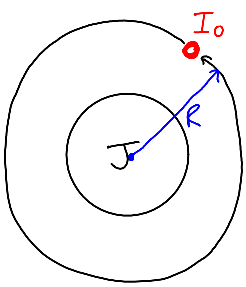
3rd law

for sun

$$T^2 = \frac{4\pi^2 R^3}{g M_s}$$

for jupiter

$$T^2 = \frac{4\pi^2 R^3}{g M_J}$$



$R = 4.22 \times 10^5$ km

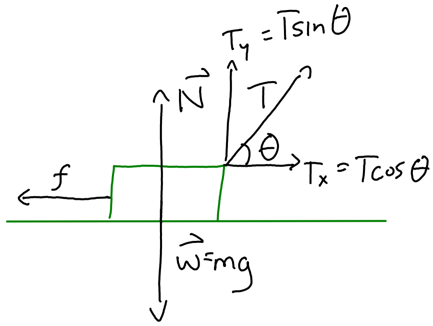
$T = 1.77 \times 24 \times 60 \times 60$ sec

$M_J = 1.9 \times 10^{27}$ kg

Midterm Review

Tuesday, November 11, 2008
5:04 PM

(2)



$f_s \leq \mu_s n$ Static problem $\vec{a} = 0$

$\vec{F}_T = 0$

$\Sigma F_x = 0$

$\Sigma F_y = 0$

$\Sigma F_x = T\cos\theta - \mu_s n = 0$

$T\cos\theta = \mu_s n = 0$

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

smallest tension

$n = \dfrac{T\cos\theta}{\mu_s}$

$\dfrac{T\cos\theta}{\mu_s} + T\sin\theta = mg$

$T\left(\dfrac{\cos\theta}{\mu_s} + \sin\theta\right) = mg$

max of $\dfrac{\cos\theta}{\mu_s} + \sin\theta$

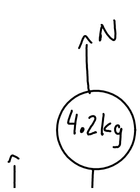
$\dfrac{d}{dt} \rightarrow -\dfrac{\sin\theta}{0.325} + \cos\theta = 0$

$\tan\theta = 0.325$ $* \tan\theta = \mu_s$

$\theta = 18^\circ$

$T \approx 4N$

(3)

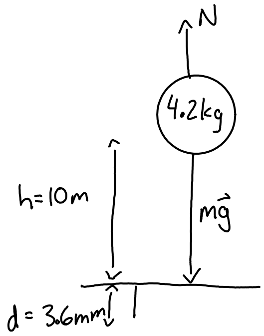


$W_f = K_f - K_i$ $K_i = 0$

$K_f = \frac{1}{2}mv^2$

$W_g = mgh = (4.2)(9.8)(10) = \frac{1}{2}mv^2$

(3)



$W_f = K_f - K_i$

$K_i = 0$

$K_f = \frac{1}{2} m v^2$

$W_g = mgh = (4.2)(9.8)(10) = \frac{1}{2} m v^2$

$\approx 400 J$

Gravity does positive work because it's force is in direction of displacement

2nd part $\underset{\text{work done by plate (neg work)}}{W} = K_f - K_i$

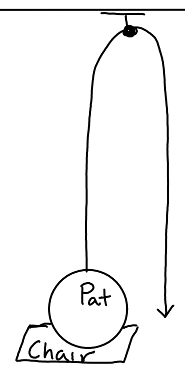
$K_f = 0 \qquad K_i < 0$

$W_p = -mgh$

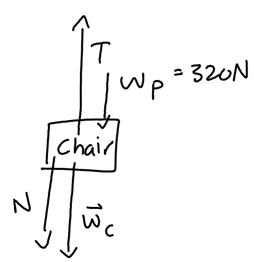
$W = \int_{x=0}^{x=-d} F_p \, dx$

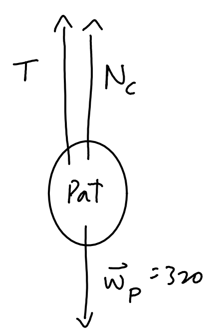
Ave force $= -\overset{\text{average}}{\overline{F_p}} d = -mgh$

$F_p = \frac{mgh}{d} \approx 10^5 N$



$T = 250N = T$





$F_{PAT} = N + 250 - 320 = 32a$

$F_{CHAIR} = 250 - N - 160 = 16a$

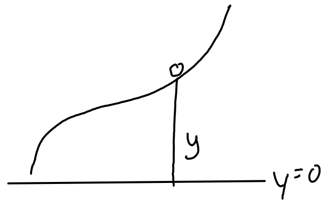
Notes 11/14

Friday, November 14, 2008
11:04 AM

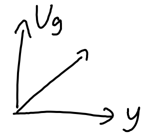
Potential Energy: Ch 7, Ch 8

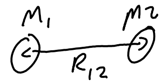
U: energy by virtue of position

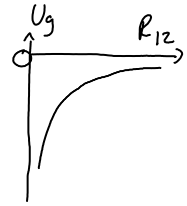
gravity



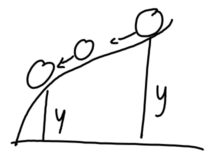
$U_g = Mgy$







$U_g = -g\frac{M_1 M_2}{R_{12}}$

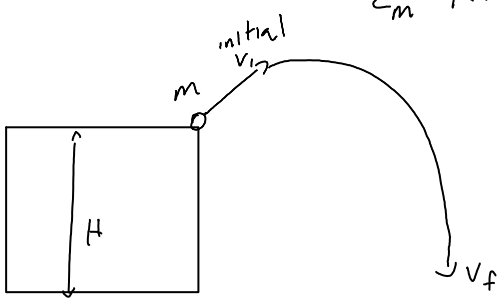


$W_g(1\to 2) =$
$Mg(y_1 - y_2)$
$U_g(1) - U_g(2)$

Energy Conservation

*Isolated mechanical system (no friction)

$\mathcal{E}_m = K + U$



Initial $\mathcal{E}_i = K + U = \frac{1}{2}mv^2 + mgH$

$\mathcal{E}_f = K + U = \frac{1}{2}mV_f^2$

$\frac{1}{2}V_f^2 = \frac{1}{2}V_1^2 + gH$

Internal Energy: $E_{int} \leftarrow$ internal energy system + environment

*heat energy

Friction: $E_H \to \mathcal{E}_{int}$

Forces:

Conservative	Nonconservative
Gravity	Friction
Electrical	Viscous drag
Potential energy	No potential energy

$\mathcal{E}_m = K + U$

constant

$W(1\to 2) = U(1) - U(2)$

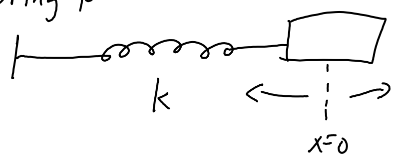
work by force depends on 1 & 2

$\mathcal{E}_M \to \mathcal{E}_{int}$

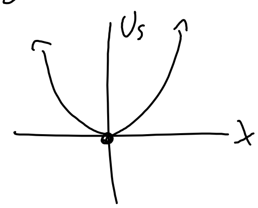
transfer

* work depends on how you go from $1 \to 2$

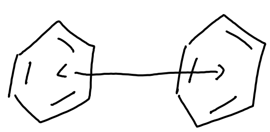
Spring force

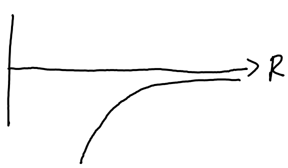


$U_s(x) = \frac{1}{2}kx^2$



$F = \frac{-dU}{dx}$ slope of U



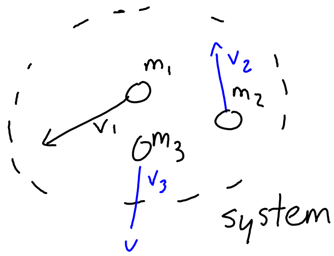


Notes 11/19

Wednesday, November 19, 2008
11:05 AM

"momentum"

$\vec{P} = \sum M_i \vec{V_i}$



$$\frac{d\vec{P}}{dt} = \vec{F}_T$$ <-- total force on system from outside

* system isolated: $\vec{P}$ constant, $\vec{F}_{TOT} = 0$

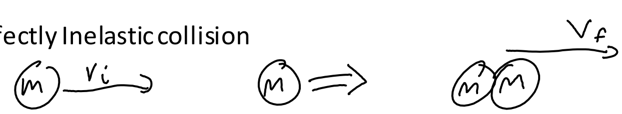
Collisions d=1

elastic: $\sum_i K_i = \text{const.}$

inelastic: $\sum_i K_i$ not constant

Elastic

Perfectly Inelastic collision



$$mV_i = 2MV_f$$
$$V_f = \frac{1}{2} V_i$$

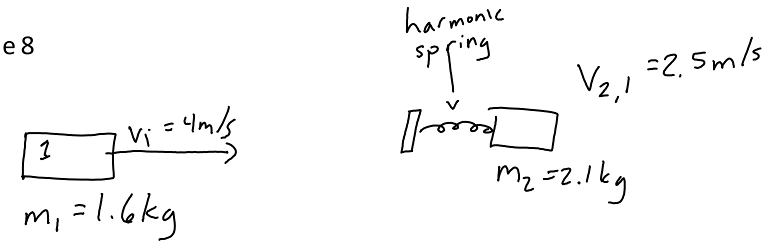
$$K_f < K_i$$

K_f: $\frac{1}{2} \times 2M \times \cancel{\frac{1}{4}}_{\frac{1}{2}} v_i^2$

$\frac{1}{2} M V_i^2$

$\frac{1}{2} M V_i^2$

Serway example 8



Final velocities?

System? no external force on 2 masses

*elastic: only if $U=0$

Before & after collision $U=0$

$$M_1 V_{1i} + M_2 V_{2i} = m_1 V_{1f} + m_2 V_{2f}$$

$$\frac{1}{2} M_1 V_{1i}^2 + \frac{1}{2} M_1 V_{2i}^2 = \frac{1}{2} m_1 V_{1f}^2 + \frac{1}{2} m_2 V_{2f}^2$$

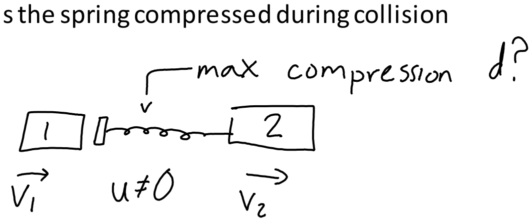
=> P conserved,
=> K conserved

2 equations, 2 unknowns

$$V_{1f} = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) V_{1i} + \left(\frac{2 M_2}{m_1 + m_2}\right) V_{2i}$$

$$V_{2f} = \left(\frac{2 m_1}{m_1 + m_2}\right) V_{1i} + \left(\frac{m_2 - m_1}{m_1 + m_2}\right) V_{2,i}$$

b) By how much is the spring compressed during collision

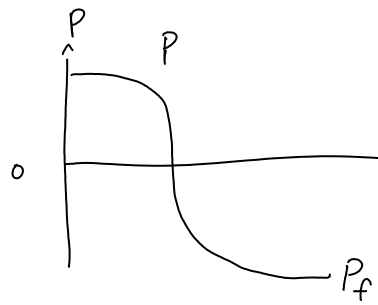


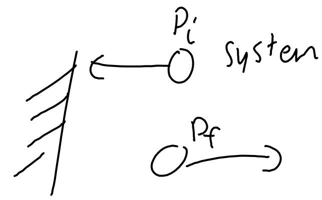
at max comp $\vec{v_1} = \vec{V_2}$ and in perfectly enelastic collision

$$V_{12} = \frac{m_1 V_{1i} + m_2 V_{2i}}{(m_1 + m_2)}$$

$$\mathcal{E} = \frac{1}{2} m_1 V_{1i}^2 + \frac{1}{2} m_2 V_{2i}^2$$

$$\mathcal{E} = \frac{1}{2} k d^2 + \frac{1}{2}(m_1 + m_2) V_{12}^2$$





Claim: Area under $F(t) \Rightarrow p_f - p_i$

$$\underbrace{\int_{t_i}^{t_f} F(t)\,dt}_{\text{impulse}} \stackrel{?}{=} \Delta p$$

Homework #8

Saturday, November 22, 2008
1:30 PM

WebAssign

Homework Ch.8 (Homework)

HEATHER CATHERINE GRAEHL
Physics 6A, Fall 2008
Instructor: Robijn Bruinsma

Current Score: 0 out of 25
Due: Monday, November 24, 2008 11:59 PM PST

---

1. [SerPOP4 8.P.001.] --/4 points

A 2.93 kg particle has a velocity of (2.95 $\hat{i}$ - 3.99 $\hat{j}$) m/s.

(a) Find its *x* and *y* components of momentum.

p_x = ______ kg·m/s
p_y = ______ kg·m/s

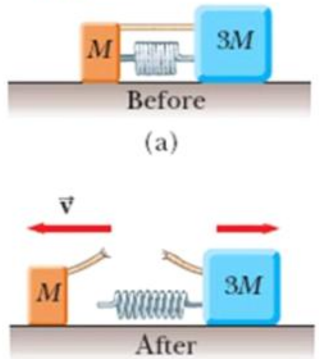
(b) Find the magnitude and direction of its momentum.

______ kg·m/s
______ ° (counterclockwise from the +*x* axis)

---

2. [SerPOP4 8.P.003.] --/4 points

Two blocks of masses *M* and 3*M* are placed on a horizontal, frictionless surface. A light spring is attached to one of them, and the blocks are pushed together with the spring between them as shown in the figure below. A cord initially holding the blocks together is burned; after that happens, the block of mass 3*M* moves to the right with a speed of 1.70 m/s.



(a) What is the velocity of the block of mass *M*? Assume right is positive and left is negative.

m/s

(b) Find the system's original elastic potential energy, taking *M* = 0.360 kg.

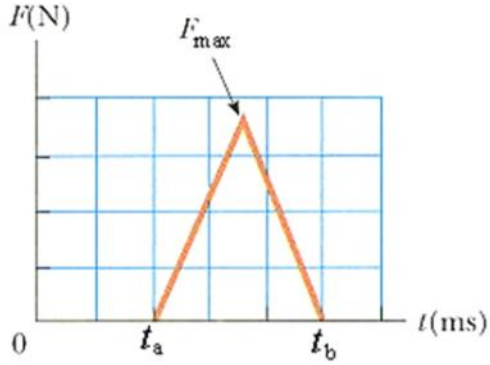
J

(c) Is the original energy in the spring or in the cord? Explain your asnwer.

(d) Is momentum of the system conserved in the bursting-apart process? How can it be, with large forces acting? How can it be, with no motion beforehand and plenty of motion afterward?

3. [SerPOP4 8.P.007.] --/3 points

An estimated force-time curve for a baseball struck by a bat is shown in the figure below. Let F_{max} = 15000 N, t_a = 1.5 ms, and t_b = 2.5 ms.



From this curve, determine each of the following.

(a) the impulse delivered to the ball
N·s

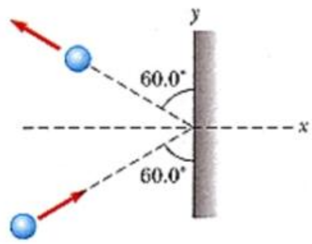
(b) the average force exerted on the ball
N

(c) the peak force exerted on the ball
N

4. [SerPOP4 8.P.009.] --/1 points

A 3.80 kg steel ball strikes a wall with a speed of 12.0 m/s at an angle of 60.0° with the surface. It bounces off with the same speed and angle. If the ball is in contact with the wall for 0.200 s, what is the average force exerted by the wall on the ball? (Assume right is the positive direction.)

N



---

5. [SerPOP4 8.P.013.AF.soln.] --/2 points

A railroad car of mass 2.44×10^4 kg is moving with a speed of 4.13 m/s. It collides and couples with three other coupled railroad cars, each of the same mass as the single car and moving in the same direction with an initial speed of 2.07 m/s.

(a) What is the speed of the four cars after the collision?

m/s

(b) How much mechanical energy is lost in the collision?

J

Hint: Active Figure 8.8

6. [SerPOP4 8.P.017.] --/2 points

Most of us know intuitively that in a head-on collision between a large dump truck and a subcompact car, you are better off being in the truck than in the car. Why? Many people imagine that the collision force exerted on the car is much greater than that experienced by the truck. To substantiate this view, they point out that the car is crushed, whereas the truck in only dented. This idea of unequal forces, of course, is false. Newton's third law tells us that both objects experience forces of the same magnitude. The truck suffers less damage because it is made of stronger metal. What about the two drivers? Do they experience the same forces? To answer this question, suppose each vehicle is initially moving at 8.0 m/s and they undergo a perfectly inelastic head-on collision. Each driver has mass 60.0 kg. Including the drivers, the total vehicle masses are 780 kg for the car and 3980 kg for the truck.
If the collision time is 0.080 s, what force does the seatbelt exert on the truck driver?

N

What average force does the seatbelt exert on the car driver?

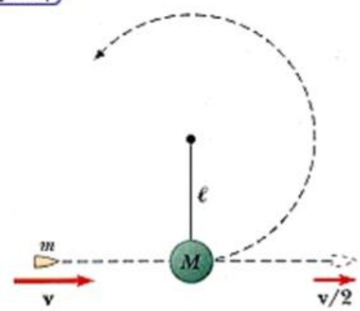
N

7. [SerPOP4 8.P.018.] --/1 points

As shown below, a bullet of mass *m* and speed *v* passes completely through a pendulum bob of mass *M*. The bullet emerges with a speed of *v*/2. The pendulum bob is suspended by a stiff rod of length ℓ and negligible mass. What is the minimum value of *v* such that the pendulum bob will barely swing through a complete vertical circle? (Use L for ℓ, g for gravity, and M and m as appropriate.)

v =

symbolic formatting help



8. [SerPOP4 8.P.024.] --/4 points

In an American football game, a 90.0 kg fullback running east with a speed of 5.06 m/s is tackled by a 94.3 kg opponent running north with a speed of 3.02 m/s.

(a) If the collision is perfectly inelastic, calculate the speed and direction of the players just after the tackle.

m/s

° (north of east)

(b) Determine the mechanical energy lost as a result of the collision.

J

Account for the missing energy.

9. [SerPOP4 8.P.027.] --/2 points

A billiard ball moving at 5.10 m/s strikes a stationary ball of the same mass. After the collision, the first ball moves at 4.23 m/s, at an angle of +34.0° with respect to the original line of motion. Assuming an elastic collision (and ignoring friction and rotational motion), find the struck ball's velocity after the collision.

m/s (magnitude)

° (with respect to the original line of motion)

---

10. [SerPOP4 8.P.034.AF.] --/2 points

A water molecule consists of an oxygen atom with two hydrogen atoms bound to it (Figure P8.34). Suppose the angle between the two bonds is 105°. If the bonds are 0.0950 nm long, where is the center of mass of the molecule? (Take the origin to be the center of the oxygen atom and the x axis to be along the dotted line.)

$x =$ nm

$y =$ nm

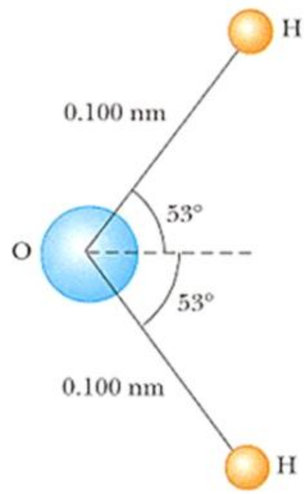


Figure P8.34

[Hint: Active Figure 8.14]

Notes 11/24

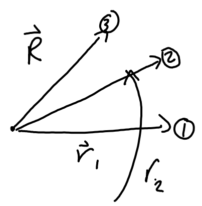
Monday, November 24, 2008
11:01 AM

Wednesday Office Hour 5-7

HW set #9

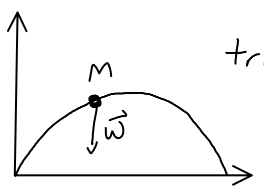
Ch 10 & 11 (1.4) due dec 5th midnight

Center of Mass



$$R_{com} = \frac{\sum_{i=1}^{N} m_i \vec{r}_i}{M}$$

total mass

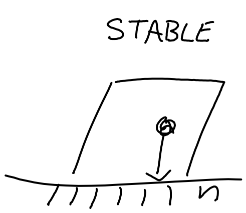


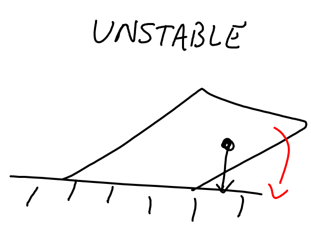
trajectory COM

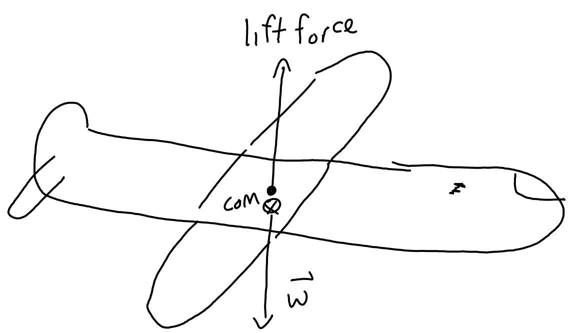
\+

rotation around COM

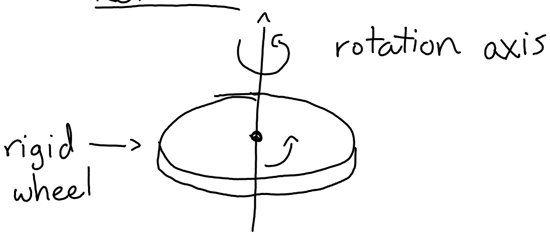
$\vec{w} = m\vec{g}$



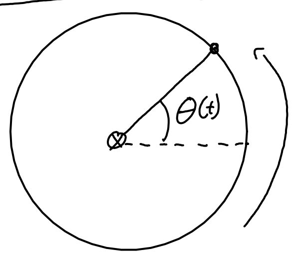




Rotation

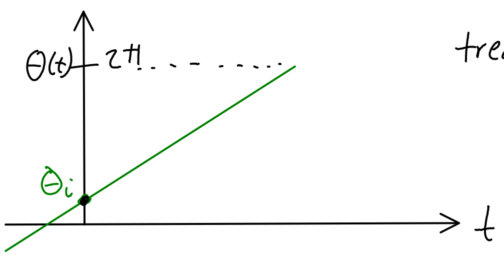


Kinematics of Rotation



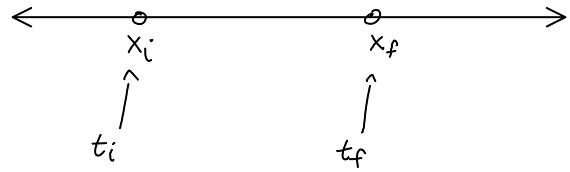
α
β
γ
⋮

$$\theta_{(rad)} = \frac{\pi}{180}\,\theta_{(degrees)}$$



treate $\theta(t)$ just like $x(t)$
$\hat{i}$ [L]

$d = 1$

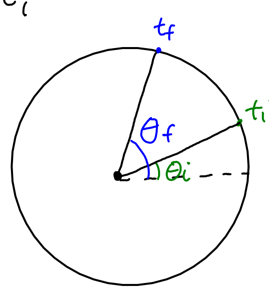


$$\Delta x = x_f - x_i$$

$$v_{AV} = \frac{\Delta x}{\Delta t}$$

define : angular velocity

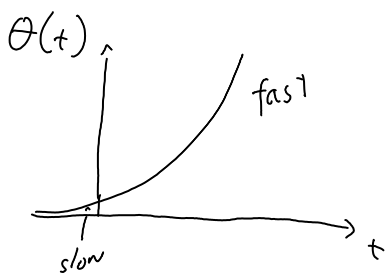
$$\omega_{AV} = \frac{\Delta\theta}{\Delta t} = \frac{\theta_f - \theta_i}{t_f - t_i}$$



Instantaneous angular velocity

$$\omega(t) = \frac{d\theta(t)}{dt}$$

ω : slope of θ vs t



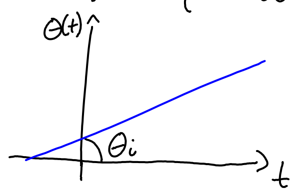
$$\alpha = \frac{d\omega}{dt}$$

instantaneous acceleration

Position		Rotation
$x(t)$	$\longleftrightarrow$	$\theta(t)$
$v = \frac{dx}{dt}$	$\longleftrightarrow$	$\omega = \frac{d\theta}{dt}$
$a = \frac{dv}{dt}$	$\longleftrightarrow$	$\alpha = \frac{d\omega}{dt}$

1) Uniform Rotation

$$\Theta(t) = \Theta_i + \omega t$$



2) Constant Acceleration a

$O \longrightarrow$

$$x(t) = x_i + v_i t + \frac{1}{2} a t^2$$

$$\Theta(t) = \Theta_i + \omega_i t + \frac{1}{2} \alpha t^2$$

$$v(t) = v_i + at$$

$$\omega(t) = \omega_i + \alpha t$$

Translation

$$K_T = \frac{1}{2} M v^2$$

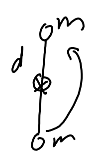
$$\text{mass} \times \left(\frac{\text{length}}{\text{time}}\right)^2$$

Rotation

$$K_R = \frac{1}{2} I \omega^2$$

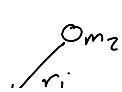
$$\text{mass} \times \text{length}^2$$

I "moment of inertia

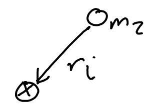


$$I = 2 \times m \times d^2$$

$$I = \sum m_i r_i^2$$



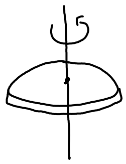
$$I = \sum m_i r_i^2$$

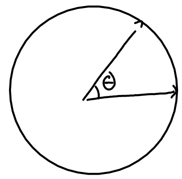


Notes 12/01

Monday, December 01, 2008
11:01 AM

Rotation





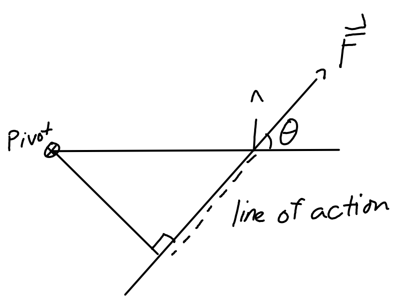
$\theta(t)$: angular displacement

$\omega = \frac{d\theta}{dt}$: angular velocity

I: { Rotational Inertia / Moment of Inertia $\Longleftrightarrow M$

$[M] \times [L]^2$

Torque $\tau \longleftrightarrow \vec{F}$



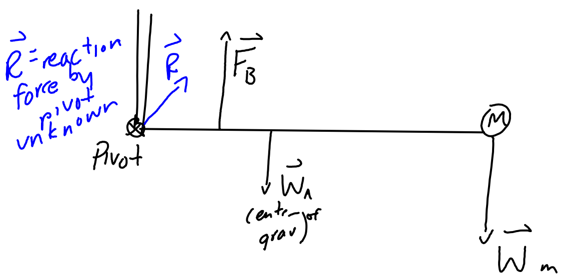
$d = r \sin\theta$

$\tau = \pm r \sin\theta F$

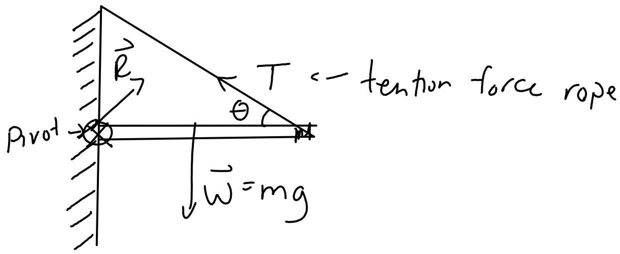
+ccw −cw

$$\boxed{\tau = I\frac{d\omega}{dt} \Longleftrightarrow \overset{N\text{II}}{F} = m\frac{dV}{dt}}$$

Arm - biceps



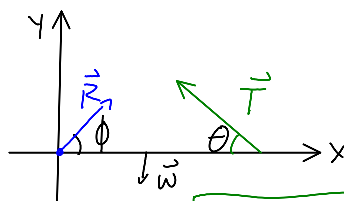
Hanging Sign



$$\vec{T}, \vec{W}, \& \vec{R}$$

Equilibrium $\Sigma \vec{F} = 0 \qquad \vec{a} = 0$

coordinate system



$\Sigma F_x = 0$

$\Sigma F_y = 0$

$$\boxed{\begin{aligned} &R\cos\theta - T\cos\theta = 0 \\ &R\sin\theta - M_g + T\sin\theta = 0 \end{aligned}}$$

$*\ \Sigma \tau' = 0$ equilibrium

$\tau_R = 0$

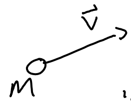
$$\tau_w = -\tfrac{1}{2} L \underbrace{Mg}_{F}$$

$$\tau_T = T\sin\theta$$

$$\tau_R + \tau_w + \tau_T = 0$$

$$0 - \tfrac{1}{2} L M_g + T\sin\theta\, L = 0 \quad \longrightarrow \quad \boxed{T = \frac{\tfrac{1}{2} Mg}{\sin\theta}}$$

Momentum



$\vec{P} = m\vec{v}$

"angular momentum"

$$L = I\omega \qquad \otimes\ \omega$$

$$[L] = [I] \times [\omega] = [M][L]^2/[I]$$

Momentum $\vec{F}_T = \dfrac{d\vec{P}}{dt}$

Angular Momentum $\tau_T = \dfrac{dL}{dt}$

* Special Case

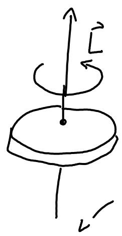
$\tau_T = 0$

L is constant

Notes 12/03

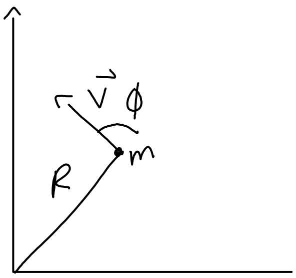
Wednesday, December 03, 2008
11:03 AM

Angular Momentum



moment of inertia

$L = I\omega$



$L = MVr\sin\phi$

Conservation Law

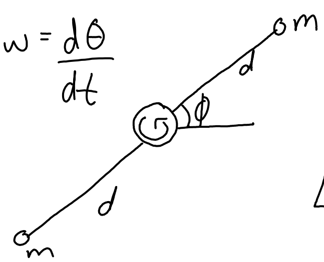
$P = m\vec{v}$

$\frac{d}{dt}L = \tau$

torque applied

$\frac{d\vec{P}}{dt} = \vec{F}$ $\quad \boxed{\tau' = Fd}$

$\omega = \frac{d\theta}{dt}$

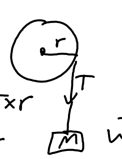


$I = 2md^2$

$L = I\omega$

Find $\alpha = \frac{d\omega}{dt}$

1) What is torque τ?



$\tau = T \times r$
$= Mgr$

$\vec{w} = mg$

2) Apply N II

$\tau = \frac{dL}{dt}$

$Mar = dL$

$$\underbrace{Mgr}_{\tau} = \frac{dL}{dt}$$

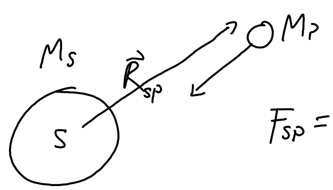
$$Mgr = \frac{d(I\omega)}{dt} = I\underbrace{\left(\frac{d\omega}{dt}\right)}_{\alpha}$$

$$\alpha = \frac{\tau}{I} = \frac{Mgr}{2md^2}$$

Mechanics solar system

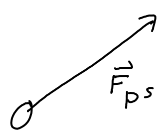
- NI, NII, NIII
- Conservatio nLaws
- Energy: momentum, angular

1) Universal Law of gravitation
   a. *holds solar system together



$$F_{sp} = -g\frac{M_s M_p}{R_{sp}^2}$$

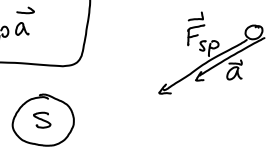
* N_{III}



$$\vec{F}_{ps} = -\vec{F}_{sp}$$

$\hat{r}$ unit vector sum $\longrightarrow$ planet

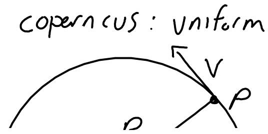
*N_{II} $\boxed{\vec{F}_{sp} = M_p\vec{a}}$

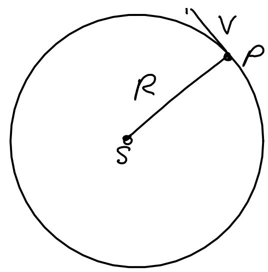


$\longrightarrow$ acceleration $\vec{a}$ from $P \longrightarrow S$

Special Case

copernicus: uniform circular motion





$$a = \frac{v^2}{R}$$

$$M_p\left(\frac{V^2}{R}\right) = g\frac{M_s M_p}{R^2} \qquad v^2 = g\frac{M_s}{R}$$

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

T = orbital period

$$\left(\frac{2\pi R}{T}\right)^2 = g\frac{M_s}{R}$$

Keplars 3rd Law

$$\Rightarrow \boxed{R^3 = \left(\frac{gM_s}{4\pi^2}\right)T^2}$$

$$v = \frac{2\pi R}{\tau}$$

Angular Velocity

$$\omega = \frac{\Delta\theta}{\Delta t} = \frac{2\pi}{\tau}$$

Angular Momentum

$$L = M_p V R$$

$$L = (M_p R^2)\omega$$

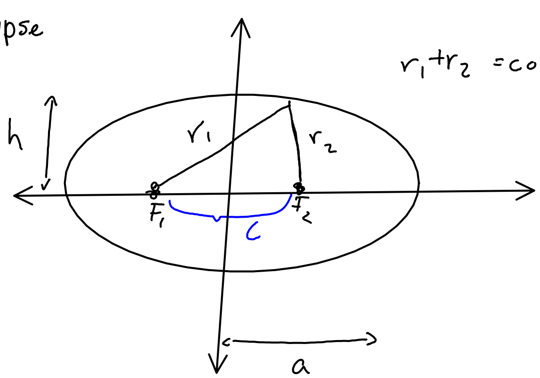
Though orbit is not circular:

Keplar's first Law

A planet moves in an elliptical orbit with the sun as a focus

Ellipse

$r_1 + r_2$ = constant



h: semi minor axis

a: semi major axis

$a^2 + b^2 = c^2$

eccentricity

$e = \frac{c}{a}$

circle

$c = 0, e = 0$

elongated ellipse $e \sim 1$

$e_{EARTH} = 0.017$

$e_{PLUTO} = 0.25$

$e_{HALLEY} = 0.97$

Angular Momentum $L_P = L_A$

$L_P = M_p V_p r_p$

$L_A = M_p V_a r_a$

$M_p V_p r_p = M_p V_a r_A$

$\left(\frac{V_P}{V_a}\right) = \left(\frac{r_A}{r_P}\right)$

$r_A >> r_r$

$V_A << V_p$

Keplar's 2nd Law

A planet moves in an elliptical orbit until the sun as a forces

Notes 12/05

Friday, December 05, 2008
10:57 AM

Today: extra office hours, J Hansen 2-3pm
Monday review 5-7pm MS4000A

Tuesday: FINAL Last name A-L PAB 1425.
Final 8

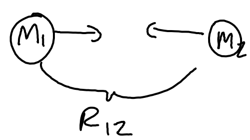
Not covered from serway
Ch 7: 7.8
Ch 8: 8.7
Ch 10: 10.10 & 10.12

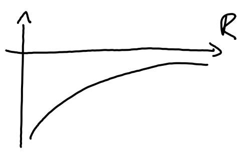
Review Chapters: 7,8,10 and 11.4

Chapter 7: Potential energy

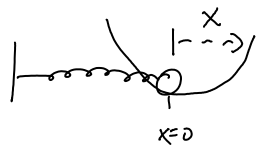
$U_g = mgy$

$$U_g = -\frac{g M_1 M_2}{R_{12}}$$

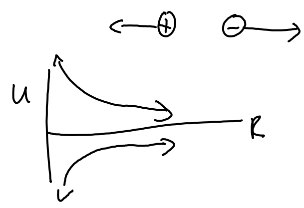




$$U_s = \frac{1}{2} k x^2$$



$$U_e = \frac{k_e q_1 q_2}{R_{12}}$$

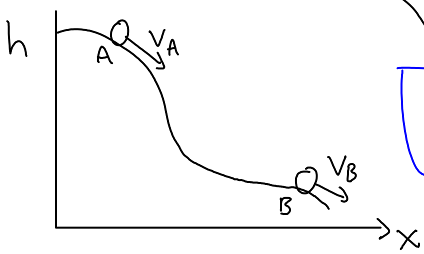


① Isolated System (no friction)

$$\boxed{\mathcal{E} = K + U}$$

$\boxed{\text{Constant}}$

$\Delta \mathcal{E} = 0 \rightarrow \Delta K + \Delta U = 0$



$$\boxed{\left(\frac{1}{2} m v_B^2 - \frac{1}{2} m v_A^2\right) + \left(mgy_B - mgy_A\right) = 0}$$

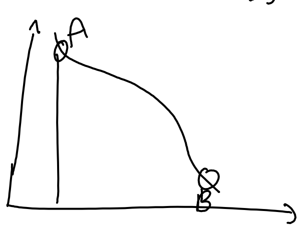
(2)

$$F_x = \frac{-dU}{dx}$$

$$F = \frac{-dU}{dR}$$

force exerted is conservative

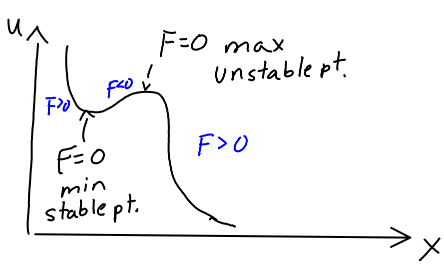
(3) $\Delta W (A \rightarrow B) = U(A) - U(B)$



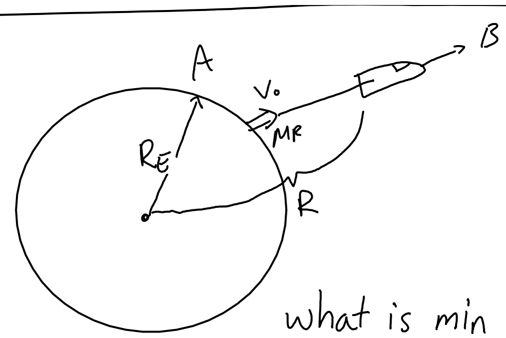
$$\int_A^B F \cdot dx = W$$

$$\boxed{\Delta W_f = mgy_A - mgy_B}$$

(4)



$$F = -\frac{dU}{dx}$$



what is min velocity of V_0
so the rocket does not fall back

$$\boxed{\mathcal{E} = -\frac{g M_E M_R}{R} + \frac{1}{2} M_R V^2}$$

$$\mathcal{E}(A) = -\frac{g M_E M_R}{R_E} + \frac{1}{2} M_R V_0^2$$

$$\mathcal{E}(B) = \frac{1}{2} M_R V_B^2 \quad \text{outer space}$$

$$\mathcal{E}(A) = \mathcal{E}(B)$$

$$-\frac{g M_E M_R}{R_E} + \frac{1}{2} M_R V_0^2 - \frac{1}{2} M \overset{0}{V^2}(B)$$

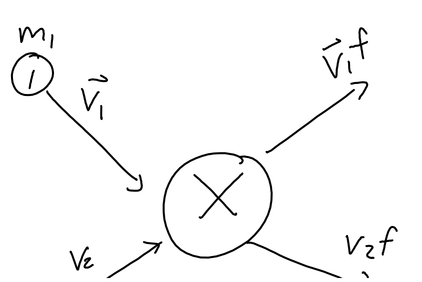
$$\frac{1}{2} \cancel{M_R} V_0^2 = \underbrace{\frac{g M_E}{R_E}}_{g} \cancel{M_R}$$

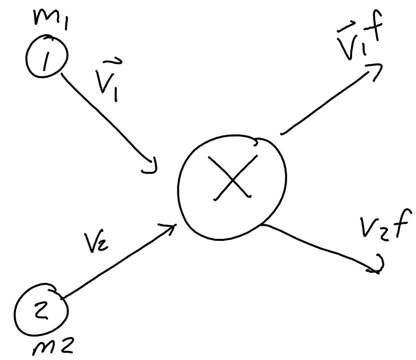
$$\frac{1}{2} V_0^2 = g R_E$$

Chapter 8

$$\vec{F} = \frac{d\vec{P}}{dt} \xRightarrow[\vec{F}=0]{} \vec{P} \text{ constant}$$

force on system





$$\vec{P} = \vec{P}_1 + \vec{P}_2 \quad \text{constant}$$

$$\boxed{m_1 \vec{v}_1 i + m_2 \vec{v}_2 i = m_1 \vec{v}_1 f + m_2 \vec{v}_2 f} \leftarrow \text{always true}$$

Elastic collision

$$K_i = K_f$$

$$\frac{1}{2} m_1 v_1 i^2 + \frac{1}{2} m_2 v_2 i^2 = \frac{1}{2} m_1 v_1^2 f + \frac{1}{2} m_2 v_2^2 f$$

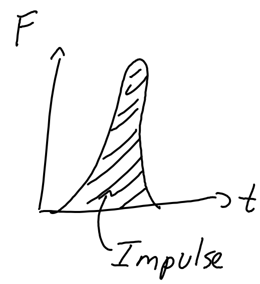
Completely Inelastic

$$\vec{v}_1 f = \vec{v}_2 f$$

- $\vec{F}_{AVE}$ on m_1?

$$I = \int_{t_1}^{t_2} \vec{F}\, dt$$

$\vec{F}$: force on m_1

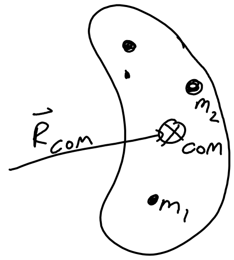


$$\Delta \vec{P}_1 = \vec{I} = \vec{F}_{AV}\, \tau$$

$\Delta \vec{P}_1$: change in momentum of 1

τ: collision time

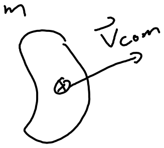
- Center of mass



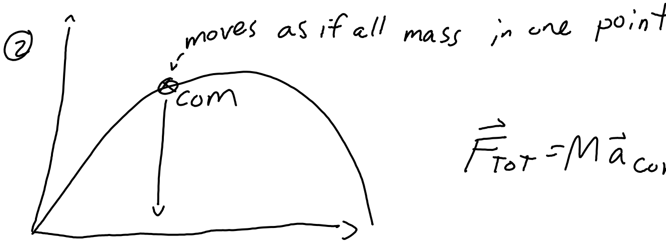
$$\vec{R}_{com} = \Sigma \frac{m_i r_1}{M}$$

Key properties of CoM

① $\vec{P} = M\vec{V}_{com}$



②



$$\vec{F}_{TOT} = M\vec{a}_{com}$$

③