Physics 211 Exam 2 Fall 2013

Last Name:________________First Name ________________ID ________________

Discussion Section:________Discussion TA Name:_________________________

Instructions—
**Please turn off your cell phone and put it away.**
**Calculators may not be shared. Please keep yours on your own desk.**
**This is a closed book exam. You have ninety (90) minutes to complete it**.

1. Use a #2 pencil. Do not use a mechanical pencil or pen. Darken each circle completely, but stay within the boundary. If you decide to change an answer, erase vigorously; the scanner sometimes registers incompletely erased marks as intended answers; this can adversely affect your grade. Light marks or marks extending outside the circle may be read improperly by the scanner. Be especially careful that your mark covers the center of its circle.

2. Print your **NETWORK ID** in the designated spaces at the right side of the answer sheet, starting in the left most column, then **mark the corresponding circle** below each character. If there is a letter "o" in your NetID, be sure to mark the "o" circle and not the circle for the digit zero. If and only if there is a hyphen "-" in your NetID, mark the hyphen circle at the bottom of the column. When you have finished marking the circles corresponding to your NetID, check particularly that you have not marked two circles in any one of the columns.

3. Print **YOUR LAST NAME** in the designated spaces at the left side of the answer sheet, then mark the corresponding circle below each letter. Do the same for your **FIRST NAME INITIAL**.

4. **You may find the version of this Exam Booklet at the top of the next page.** Mark the version circle in the TEST FORM box at the bottom right on your answer sheet. **DO THIS NOW!**

5. Print your UIN# in the **STUDENT NUMBER** designated spaces and mark the corresponding circles. You need not write in or mark the circles in the SECTION box

6. Sign your name (**DO NOT PRINT**) on the **STUDENT SIGNATURE** line.

7. On the **SECTION** line, print your **DISCUSSION SECTION**. You need not fill in the COURSE or INSTRUCTOR lines.

Before starting work, check to make sure that your test booklet is complete. In addition to these instructions, you should have 10 numbered pages plus one (1) Formula Sheet.

*Academic Integrity*: **Giving assistance to or receiving assistance from another student or using unauthorized materials during a University Examination can be grounds for disciplinary action, up to and including expulsion.**

**This Exam Booklet is Version A**. Mark the **A** circle in the TEST FORM box at the bottom right on your answer sheet. **DO THIS NOW!**

Exam Grading Policy—

The exam is worth a total of **102** points, composed of two types of questions.

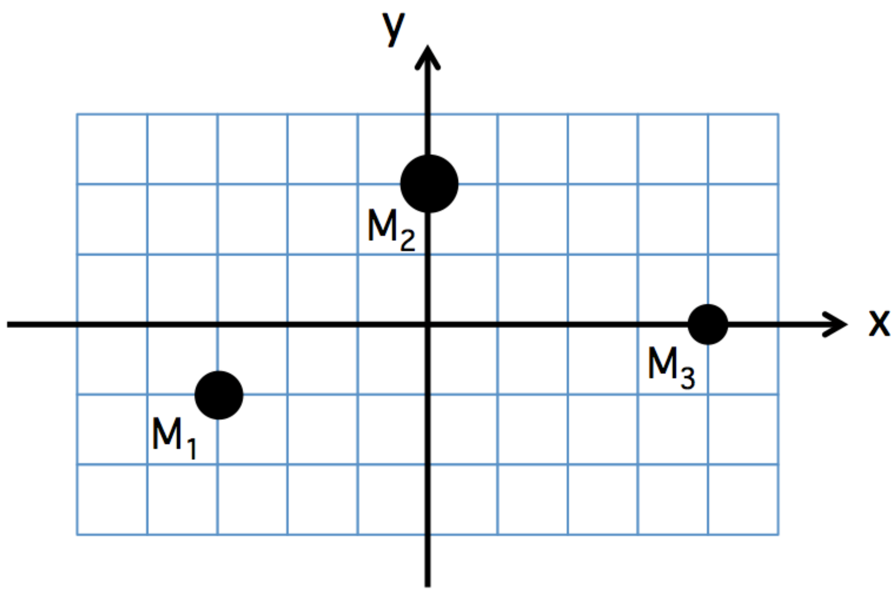
**MC5**: *multiple-choice-five-answer questions, each worth 6 points.*
Partial credit will be granted as follows.

A) If you mark only one answer and it is the correct answer,
you earn **6** points.
B) If you mark two answers, one of which is the correct answer,
you earn **3** points.
C) If you mark three answers, one of which is the correct answer,
you earn **2** points.
D) If you mark no answers, or more than three, you earn 0 points.

**MC3**: *multiple-choice-three-answer questions, each worth 3 points*.
**No partial credit**.

A) If you mark only one answer and it is the correct answer,
you earn 3 points.
B) If you mark a wrong answer or no answers, you earn 0 points.

**The next two questions pertain to the situation described below.**




Three objects are located in the x-y plane as shown in the diagram. The axes intersect at (0,0), and the spacing of the lines in the grid is 1 m. The masses of the objects are $M_1$ = 4 kg, $M_2$ = 6 kg, and $M_3$ = 3 kg.

1) What is the (x,y) coordinate of the center of mass of the system?

a. (0.33 m, 0.33 m)
b. (0 m, 0.8 m)
c. (0.5 m, 0.5 m)
d. (0 m, 0.62 m)
e. (0 m, 0.89 m)

2) Suppose a force of 4 N acts on $M_1$ in the -x direction and a force of 6 N acts on $M_2$ in the +x direction. What is the magnitude of the acceleration of the center of mass of the system?

a. $A_{cm}$ = 0 m/s$^2$
b. $A_{cm}$ = 0.15 m/s$^2$
c. $A_{cm}$ = 0.2 m/s$^2$
d. $A_{cm}$ = 0.1 m/s$^2$
e. $A_{cm}$ = 0.5 m/s$^2$

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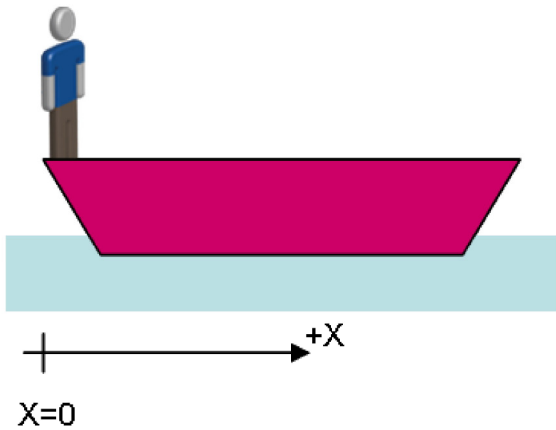



A man with mass $m_1$ = 57 kg stands at the left end of a uniform symmetric boat with mass $m_2$ = 160 kg and a length L = 3.2 m. Let the origin of our coordinate system be the man's original location as shown in the drawing. Assume there is no friction or drag between the boat and water.

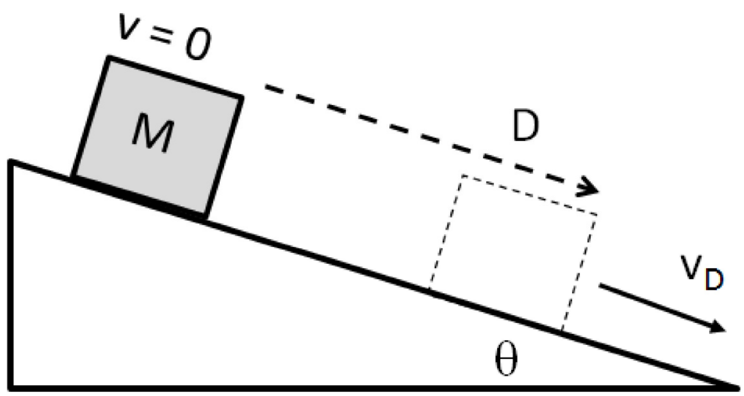
3) The man walks to the center of the boat. As he does this, what happens to the location of the center of mass of the man-boat system?

a. It moves to the right.
b. It does not move.
c. It moves to the left.

4) When the man reaches the center of the boat, what is his new X coordinate?

a. $X_{new}$ = 1.18 m
b. $X_{new}$ = 2.36 m
c. $X_{new}$ = 1.6 m
d. $X_{new}$ = 3.2 m
e. $X_{new}$ = 0.84 m

**The next three questions pertain to the situation described below.**




A box of mass M = 3 kg is initially held at rest near the top of a frictionless ramp that makes an angle of $\theta$ = 20 degrees with respect to the horizontal. When the box is released it accelerates down the ramp.

5) The total work done by all forces on the box as it moves a distance D down the ramp is:

a. Positive
b. Negative
c. Zero

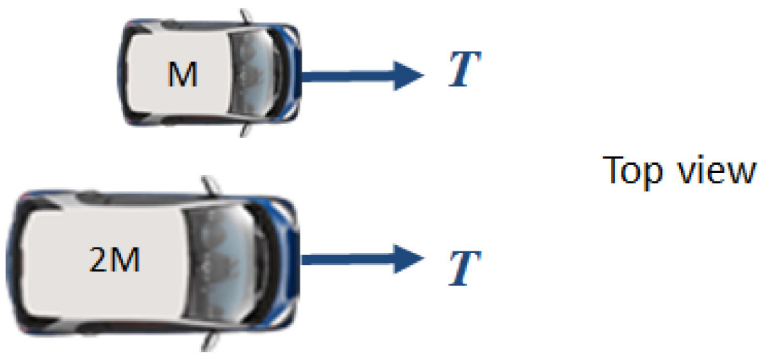
6) After the box has moved a distance $D$ = 1.1 m down the ramp from its starting point, what is its speed?

a. $V_D$ = 5.19 m/s
b. $V_D$ = 4.65 m/s
c. $V_D$ = 2.72 m/s
d. $V_D$ = 4.5 m/s
e. $V_D$ = 2.48 m/s

7) Now suppose that there is friction between the box and the ramp, but that the box still accelerates down the ramp. The kinetic coefficient of friction is $\mu_K$ . As the box moves a distance $D$ down the ramp, the total work done on it by friction is

a. $-\mu_K MgDcos\theta$
b. $-\mu_K MgD$
c. $-\mu_K MgDsin\theta$

**The next two questions pertain to the situation described below.**




Two cars, one a compact car of mass M, the other a full-size car of mass 2M, are each being pulled in the same direction on level ground by horizontal ropes having equal tension $T$ . Assume that both cars start from rest and that there are no other horizontal forces acting.

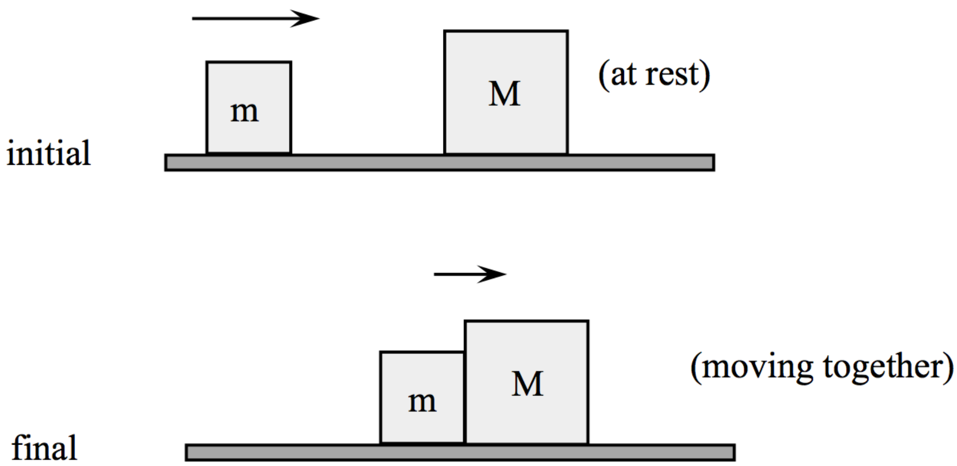
8) If both cars are pulled in this way for the same amount of time, which statement is true at the end of the pulls?

   a. The cars have the same momentum but different kinetic energies.
   b. The cars have the same kinetic energy but different momentum.
   c. The cars have both the same momentum and the same kinetic energy.

9) If both cars are pulled in this way for the same total distance, which statement is true at the end of the pulls?

   a. Both cars have the same speed but different momentum.
   b. Both cars have the same kinetic energy but different speeds.
   c. Both cars have the same momentum but different kinetic energy.

**The next two questions pertain to the situation described below.**




A box of mass m sliding on a frictionless horizontal air-track collides and sticks to a second box of mass M = 5m which is initially at rest. After the collision, the boxes move together.

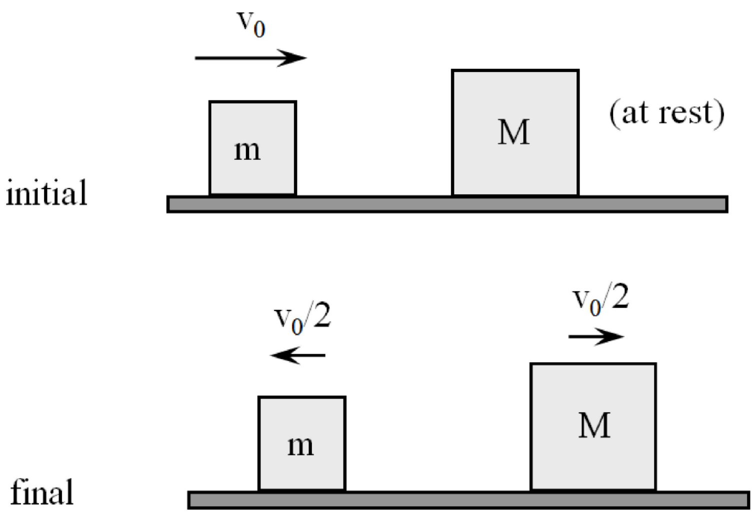
10) What is the ratio of the final to the initial kinetic energy of the system, $K_f/K_i$ ?
(Hint: recall that $K = \frac{p^2}{2m}$ )

a. $K_f/K_i$ = 1/5
b. $K_f/K_i$ = 1/1
c. $K_f/K_i$ = 1/4
d. $K_f/K_i$ = 1/6
e. $K_f/K_i$ = 1/7

11) Suppose the answer to the above question is $R$ . If instead the box of mass M = 5m was initially sliding and it collided and stuck to the box of mass m, which was initially at rest, how would the ratio of the final to the initial kinetic energy of the system compare to $R$ ?

a. It would be bigger than $R$ .
b. It would be smaller than $R$ .
c. It would be equal to $R$ .

**The next two questions pertain to the situation described below.**




A box of mass m slides on a frictionless horizontal air-track with an initial speed $V_0$ . It collides and bounces off a box of mass M which is initially at rest. After the collision the boxes have the same speed, $V_0/2$ , one moving to the left and the other to the right as shown.

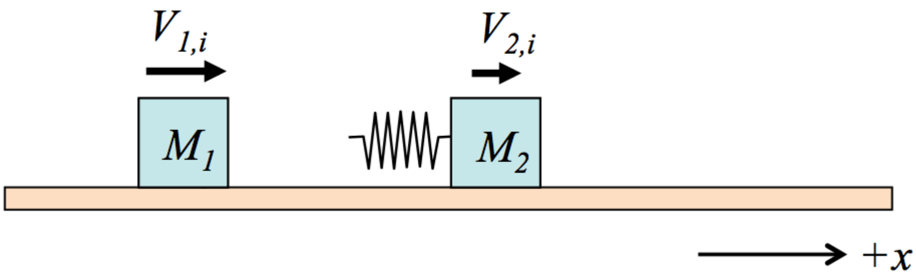
12) Which of the following statements is true?

a. We need to know the masses of the boxes in order to determine whether or not the collision is elastic.
b. The collision is not elastic, and this can be determined without knowing the masses of the boxes.
c. The collision is elastic, and this can be determined without knowing the masses of the boxes.

13) How are the masses of the two boxes related? (Hint: You only need to consider momentum conservation)

a. M = 3m/2
b. M = 3m
c. M = 4m
d. M = 2m/3
e. M = 2m

**The next three questions pertain to the situation described below.**




A block of mass $M_1$ = 2 kg is moving to the right with initial speed $V_{1,i}$ = 3.4 m/s. It collides with another block of mass $M_2$ = 3 kg that is initially moving to the right with $V_{2,i}$ = 1.7 m/s. There is a massless spring connected to the second block as shown, and the collision between the blocks is elastic. All motion is in one dimension and the +x direction is to the right in the picture.

14) What is the velocity of the center of mass of the system?

a. $V_{cm}$ = 1.95 m/s
b. $V_{cm}$ = 1.36 m/s
c. $V_{cm}$ = 2.38 m/s
d. $V_{cm}$ = 2.55 m/s
e. $V_{cm}$ = 3.4 m/s

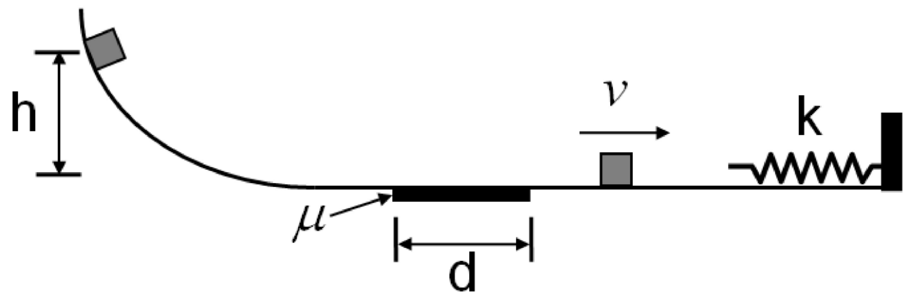
15) As measured by someone in the center of mass reference frame, in what direction is $M_2$ moving before the collision.

a. In the -x direction.
b. $M_2$ is at rest in the center of mass reference frame.
c. In the +x direction.

16) At the instant during the collision when the compression of the spring is maximum, both blocks move with the same velicity as the center of mass, $V_{cm}$ . At this instant, which of the following correctly expresses the potential energy stored in the spring $U_{spring}$ ?

a. $U_{spring} = \frac{1}{2} (M_1 + M_2) V_{cm}^2$
b. $U_{spring} = \frac{1}{2} M_1 V_{1,i}^2 + \frac{1}{2} M_2 V_{2,i}^2 + \frac{1}{2} (M_1 + M_2) V_{cm}^2$
c. $U_{spring} = \frac{1}{2} M_1 V_{1,i}^2 + \frac{1}{2} M_2 V_{2,i}^2 - \frac{1}{2} (M_1 + M_2) V_{cm}^2$
d. $U_{spring} = \frac{1}{2} M_1 V_{1,i}^2 - \frac{1}{2} M_2 V_{2,i}^2$
e. $U_{spring} = \frac{1}{2} M_1 V_{1,i}^2 + \frac{1}{2} M_2 V_{2,i}^2$

**The next three questions pertain to the situation described below.**




A block of mass m = 0.3 kg starts at rest a height h above the horizontal bottom of a track. The track is completely frictionless, with the exception of a rough horizontal section of track having length d = 0.91 m which has a coefficient of kinetic friction $\mu$ = 0.2. After passing over the rough section the speed of the of the block is $v$ = 4.82 m/s.

17) What was the starting height h of the block ?

a. h = 1.55 m
b. h = 1 m
c. h = 1.37 m
d. h = 1.09 m
e. h = 1.18 m

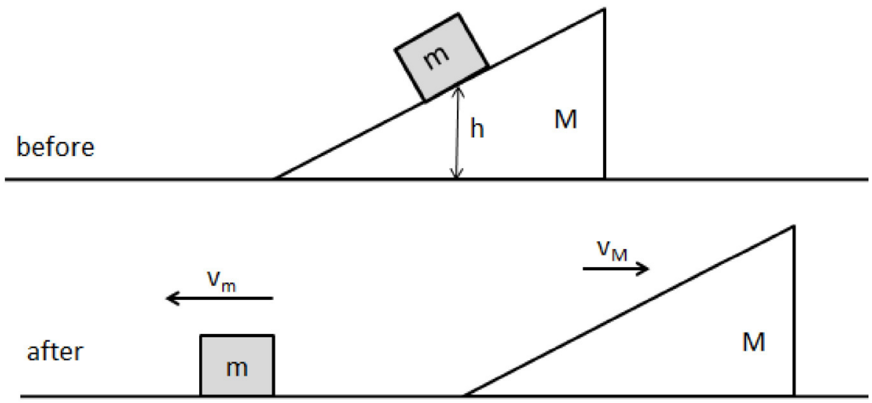
18) If the mass of the block is increased, but we want its speed after passing over the rough section to be the same as above, how would its starting height have to change?

a. The starting height h would stay the same.
b. The starting height h would have to decrease.
c. The starting height h would have to increase.

19) At the end of the track the block bounces off a spring having constant k. The other end of the spring is attached to a wall, and the collision between the spring and the block is elastic. What is the maximum compression of the spring during the collision?

a. $\Delta x = v\sqrt{k/m}$
b. $\Delta x = v\sqrt{m/k}$
c. $\Delta x = m\sqrt{v/k}$

**The next three questions pertain to the situation described below.**




A block of mass m is initially at rest a height h above the bottom of a wedge of mass M = 3m, as shown in the diagram labeled "before". The system is released from rest, and the second diagram shows the situation after the block has slid down the wedge and onto to the horizontal table below, with the block moving to the left with speed $V_m$ and the wedge moving to the right with speed $V_M$ . All surfaces are frictionless and there are no external horizontal forces acting on the system.

20) Which statement best relates the speeds of the wedge and the block after the block has slid onto the table?

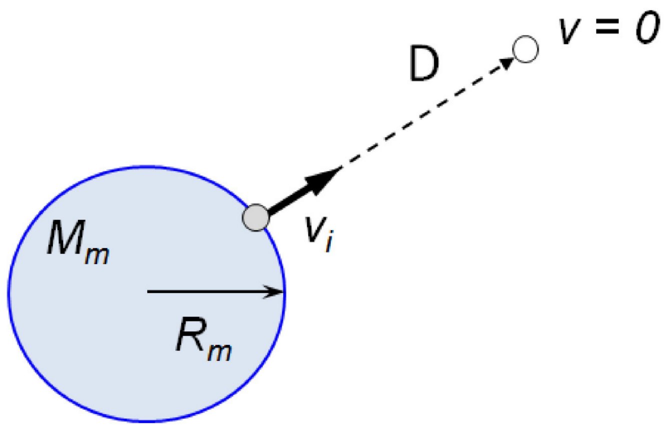
a. $V_M < V_m$
b. $V_M > V_m$
c. $V_M = V_m$

21) Which statement best relates the kinetic energy of the wedge, $K_M$ , and the kinetic energy of the block, $K_m$ , after the block has slid onto the table?

a. $K_M = K_m$
b. $K_M > K_m$
c. $K_M < K_m$

22) Suppose the speed of the block after is slides onto the table is $V_m$ = 1.5 m/s. What was the starting height of the block h ?

a. h = 0.23 m
b. h = 0.15 m
c. There is not enough information provided to determine h
d. h = 0.46 m
e. h = 0.11 m




A cannon on the surface of the moon fires a shell directly upward with initial speed $V_i$ . The shell rises a distance of $D = 3.045 \times 10^6$ m above the lunar surface before stopping and falling back down again.

The mass of the Moon is $M_m = 7.35 \times 10^{22} kg$ , the radius of the Moon is $R_m = 1.74 \times 10^6 m$ and the universal gravitational constant is $G = 6.67 \times 10^{-11} Nm^2/kg^2$ .

23) What was the shell's initial speed, $V_i$ ?

a. $V_i$ = 9275 m/s.
b. $V_i$ = 7729 m/s.
c. $V_i$ = 1578 m/s.
d. $V_i$ = 1339 m/s.
e. $V_i$ = 1894 m/s.

# Phys 211 Formula Sheet

***Kinematics***

$\mathbf{v} = \mathbf{v}_0 + \mathbf{a}t$

$\mathbf{r} = \mathbf{r}_0 + \mathbf{v}_0 t + at^2/2$

$v^2 = v_0^2 + 2a(x-x_0)$

$g = 9.81\ m/s^2 = 32.2\ ft/s^2$

$\mathbf{v}_{A,B} = \mathbf{v}_{A,C} + \mathbf{v}_{C,B}$

***Uniform Circular Motion***

$a = v^2/r = \omega^2 r$

$v = \omega r$

$\omega = 2\pi/T = 2\pi f$

***Dynamics***

$\mathbf{F}_{net} = m\mathbf{a} = d\mathbf{p}/dt$

$\mathbf{F}_{A,B} = -\mathbf{F}_{B,A}$

$F = mg$ (near earth's surface)

$F_{12} = -Gm_1m_2/r^2$ (in general)

(where $G = 6.67\times10^{-11}\ Nm^2/kg^2$)

$\mathbf{F}_{spring} = -k\,\boldsymbol{\Delta}\mathbf{x}$

***Friction***

$f = \mu_k N$ (kinetic)

$f \le \mu_S N$ (static)

***Work & Kinetic energy***

$W = \int \mathbf{F}\cdot\mathbf{dl}$

$W = \mathbf{F}\cdot\boldsymbol{\Delta}\mathbf{r} = F\,\Delta r\,\cos\theta$

(constant force)

$W_{grav} = -mg\Delta y$

$W_{spring} = -k(x_2^2 - x_1^2)/2$

$K = mv^2/2 = p^2/2m$

$W_{NET} = \Delta K$

***Potential Energy***

$U_{grav} = mgy$ (near earth surface)

$U_{grav} = -GMm/r$ (in general)

$U_{spring} = kx^2/2$

$\Delta E = \Delta K + \Delta U = W_{nc}$

***Power***

$P = dW/dt$

$P = \mathbf{F}\cdot\mathbf{v}$ (for constant force)

***System of Particles***

$\mathbf{R}_{CM} = \Sigma m_i\mathbf{r}_i / \Sigma m_i$

$\mathbf{V}_{CM} = \Sigma m_i\mathbf{v}_i / \Sigma m_i$

$\mathbf{A}_{CM} = \Sigma m_i\mathbf{a}_i / \Sigma m_i$

$\mathbf{P} = \Sigma m_i\mathbf{v}_i$

$\Sigma\mathbf{F}_{EXT} = M\mathbf{A}_{CM} = d\mathbf{P}/dt$

***Impulse***

$\mathbf{I} = \int \mathbf{F}\,dt$

$\Delta\mathbf{P} = \mathbf{F}_{av}\Delta t$

***Collisions:***

If $\Sigma\mathbf{F}_{EXT} = 0$ in some direction, then $\mathbf{P}_{before} = \mathbf{P}_{after}$ in this direction:

$\Sigma m_i\mathbf{v}_i$ (before) $= \Sigma m_i\mathbf{v}_i$ (after)

<u>In addition, if the collision is elastic:</u>

* $E_{before} = E_{after}$

* *Rate of approach = Rate of recession*

* *The speed of an object in the Center-of-Mass reference frame is unchanged by an elastic collision.*

***Rotational kinematics***

$s = R\theta,\ v = R\omega,\ a = R\alpha$

$$\left.\begin{aligned}\theta &= \theta_0 + \omega_0 t + {}^1/_2\alpha t^2\\ \omega &= \omega_0 + \alpha t\\ \omega^2 &= \omega_0^2 + 2\alpha\Delta\theta\end{aligned}\right\}$$

***Rotational Dynamics***

$I = \Sigma m_i r_i^2$

$I_{parallel} = I_{CM} + MD^2$

$I_{disk} = I_{cylinder} = {}^1/_2 MR^2$

$I_{hoop} = MR^2$

$I_{solid\text{-}sphere} = {}^2/_5 MR^2$

$I_{spherical\ shell} = {}^2/_3 MR^2$

$I_{rod\text{-}cm} = {}^1/_{12} ML^2$

$I_{rod\text{-}end} = {}^1/_3 ML^2$

$\tau = I\alpha$ (rotation about a fixed axis)

$\boldsymbol{\tau} = \mathbf{r}\times\mathbf{F}$, $|\tau| = rF\sin\phi$

***Work & Energy***

$K_{rotation} = {}^1/_2 I\omega^2$,

$K_{translation} = {}^1/_2 MV_{cm}^2$

$K_{total} = K_{rotation} + K_{translation}$

$W = \tau\theta$

***Statics***

$\Sigma\mathbf{F} = 0$, $\Sigma\tau = 0$ (about any axis)

***Angular Momentum:***

$\mathbf{L} = \mathbf{r}\times\mathbf{p}$

$L_z = I\omega_z$

$\mathbf{L}_{tot} = \mathbf{L}_{CM} + \mathbf{L}^*$

$\boldsymbol{\tau}_{ext} = d\mathbf{L}/dt$

$\boldsymbol{\tau}_{cm} = d\mathbf{L}^*/dt$

$\Omega_{precession} = \tau / L$

***Simple Harmonic Motion:***

$d^2x/dt^2 = -\omega^2 x$

(differential equation for SHM)

$x(t) = A\cos(\omega t + \phi)$

$v(t) = -\omega A\sin(\omega t + \phi)$

$a(t) = -\omega^2 A\cos(\omega t + \phi)$

$\omega^2 = k/m$ (mass on spring)

$\omega^2 = g/L$ (simple pendulum)

$\omega^2 = mgR_{CM}/I$ (physical pendulum)

$\omega^2 = \kappa/I$ (torsion pendulum)

***General harmonic transverse waves:***

$y(x,t) = A\cos(kx - \omega t)$

$k = 2\pi/\lambda,\quad \omega = 2\pi f = 2\pi/T$

$v = \lambda f = \omega/k$

***Waves on a string:***

$$v^2 = \frac{F}{\mu} = \frac{(\text{tension})}{(\text{mass per unit length})}$$

$$\bar{P} = \frac{1}{2}\mu v\omega^2 A^2$$

$$\frac{d\bar{E}}{dx} = \frac{1}{2}\mu\omega^2 A^2$$

$$\frac{d^2y}{dx^2} = \frac{1}{v^2}\frac{d^2y}{dt^2} \quad \text{Wave Equation}$$

***Fluids:***

$$\rho = \frac{m}{V} \qquad p = \frac{F}{A}$$

$$A_1v_1 = A_2v_2$$

$$p_1 + \tfrac{1}{2}\rho v_1^2 + \rho g y_1 = p_2 + \tfrac{1}{2}\rho v_2^2 + \rho g y_2$$

$$F_B = \rho_{liquid} g V_{liquid}$$

$$F_2 = F_1\frac{A_2}{A_1}$$