Physics 211 Exam 2 Spring 2014

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 9 numbered pages (24 questions) 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 **108** points, composed of two types of questions.

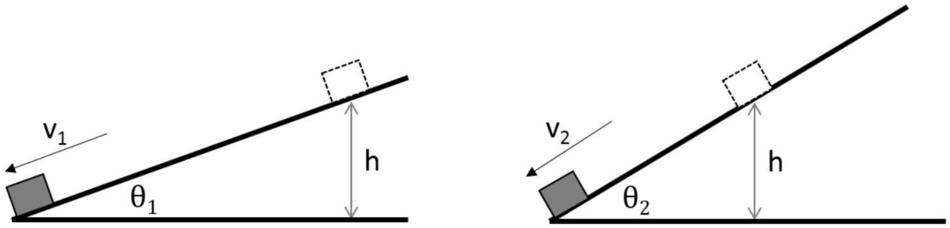
MC5: *multiple-choice-five-answer questions, each worth 6 points.*
Partial credit will be granted as follows.

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 three questions pertain to the situation described below.



Identical blocks start from rest at the same height above the floor on two different ramps. The first ramp makes a smaller angle with respect to the horizontal than the second ramp. The speed of the blocks when they reach the floor is v_1 and v_2 respectively.

1) Assume that both ramps are frictionless. Which statement is most correct concerning the relative speeds of the blocks at the bottom of the ramps?

a. $v_2 < v_1$
b. $v_2 > v_1$
c. $v_2 = v_1$

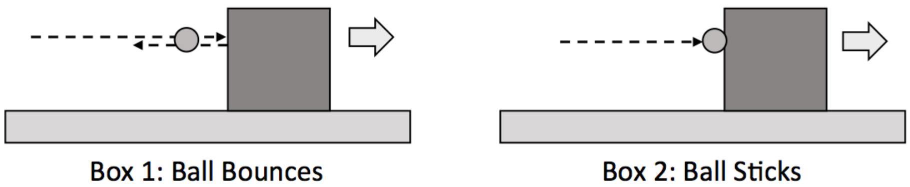
2) Now assume instead that in both cases there is the same (non-zero) coefficient of kinetic friction between the blocks and the ramps. Which statement is now most correct concerning the relative speeds of the blocks at the bottom of the ramps?

a. $v_2 = v_1$
b. $v_2 > v_1$
c. $v_2 < v_1$

3) The blocks start at height h = 1.7 m. The second ramp is inclined at an angle of $\theta_2 = 57°$. The coefficient of kinetic friction is 0.67. What is the speed v_2 when the block reaches the bottom of the second ramp?

a. $v_2 = 3.25 m/s$
b. $v_2 = 5.78 m/s$
c. $v_2 = 4.6 m/s$
d. $v_2 = 3.07 m/s$
e. $v_2 = 4.34 m/s$

The next two questions pertain to the situation described below.



Two balls of equal mass are thrown horizontally with the same initial velocity. They hit identical stationary boxes resting on a frictionless horizontal surface. The ball hitting box 1 bounces back, while the ball hitting box 2 gets stuck to the box. You can assume that there is no motion in the vertical direction before or after the collisions.

4) Which box has the greater speed after the collision?

a. Both boxes have the same speed
b. Box 2
c. Box 1

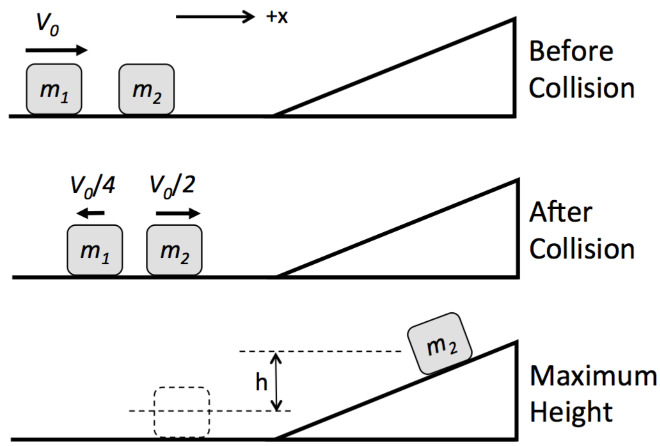
5) The mass of a box is 1.8 kg and the mass of the ball is 0.45 kg. Suppose the ball has an initial horizontal velocity of 14 m/s. What is the speed of Box 2 after the collision?

a. $v = 3.5 m/s$
b. $v = 14 m/s$
c. $v = 2.8 m/s$
d. $v = 56 m/s$
e. $v = 11.2 m/s$

The next three questions pertain to the situation described below.

Mass m_1 initially has a speed of V_0 in the $+x$ direction along a frictionless horizontal floor. It collides with mass m_2 which is initially at rest.

Immediately after the collision m_1 is moving in the $-x$ direction with speed $V_0/4$ and m_2 is moving in the $+x$ direction with speed $V_0/2$.



6) Is this collision elastic? (Hint - almost no math is needed to answer this question)

a. There is not enough information provided to determine whether the collision is elastic.
b. No, the collision is not elastic.
c. Yes, the collision is elastic.

7) Which of the following correctly expresses the relationship between the masses?

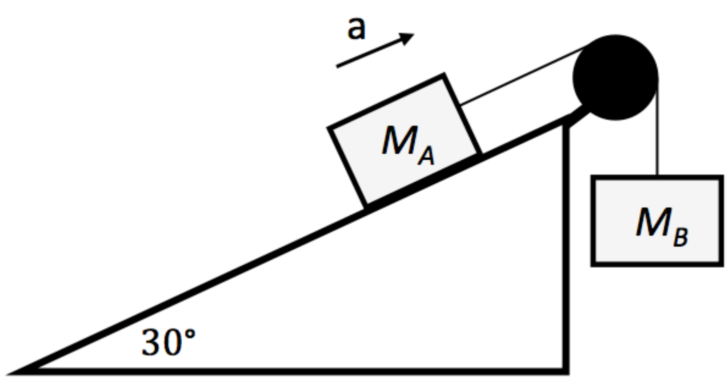
a. $m_2 = (1/2)m_1$
b. $m_2 = 2m_1$
c. $m_2 = (3/4)m_1$
d. $m_2 = (4/3)m_1$
e. $m_2 = (5/2)m_1$

8) Mass m_2 continues to the right and slides up a frictionless ramp. It momentarily comes to rest at a maximum height h above its starting height on the floor before sliding back down. Which of the following correctly expresses the maximum heigh h reached by m_2 in terms of V_0?

a. $h = v_0^2/2g$
b. $h = 4v_0^2/3g$
c. $h = v_0^2/8g$
d. $h = 3v_0^2/4g$
e. $h = v_0^2/4g$

The next three questions pertain to the situation described below.

Block A has mass M_A = 4 kg and slides on a frictionless inclined plane. It is connected to a hanging block B of mass M_B by a massless string that runs over a frictionless pulley. The incline makes an angle of 30° with horizontal. The acceleration of block A is $a = 2.1 m/s^2$ up the incline.



9) As block A moves a distance 1.3 m up the incline, what is the work done on it by the tension in the string, $W_{A,T}$?

a. $W_{A,T}$ = 36.43 J
b. $W_{A,T}$ = -14.59 J
c. $W_{A,T}$ = 55.1 J
d. $W_{A,T}$ = 10.92 J
e. $W_{A,T}$ = 0 J

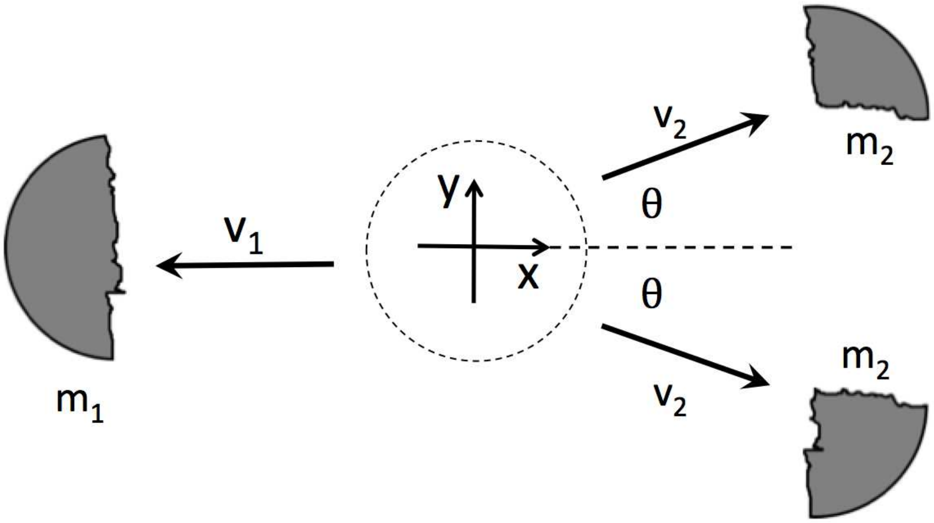
10) As block A moves a distance 1.3 m up the incline, how does the magnitude of the work done on it by the tension in the string $|W_{A,T}|$, compare to magnitude of the work done on it by gravity, $|W_{A,g}|$?

a. $|W_{A,T}| = |W_{A,g}|$
b. $|W_{A,T}| > |W_{A,g}|$
c. $|W_{A,T}| < |W_{A,g}|$

11) As block A moves a distance 1.3 m up the incline, what is the total work done <u>on both blocks</u> by the tension in the string, W_{tot}?

a. $W_{tot} = 0$
b. $W_{tot} > 0$
c. $W_{tot} < 0$

The next two questions pertain to the situation described below.



A bomb, initially at rest at the origin, explodes into three fragments that move in the *x*-*y* plane. The left fragment has mass m_1 = 26 kg and moves in the $-x$ direction with speed v_1. The fragments that move to the right have the same mass m_2 and the same speed v_2, one moving at an angle $\theta = 30^\circ$ above the x-axis, and the other moving at the same angle $\theta = 30^\circ$ below the x-axis.

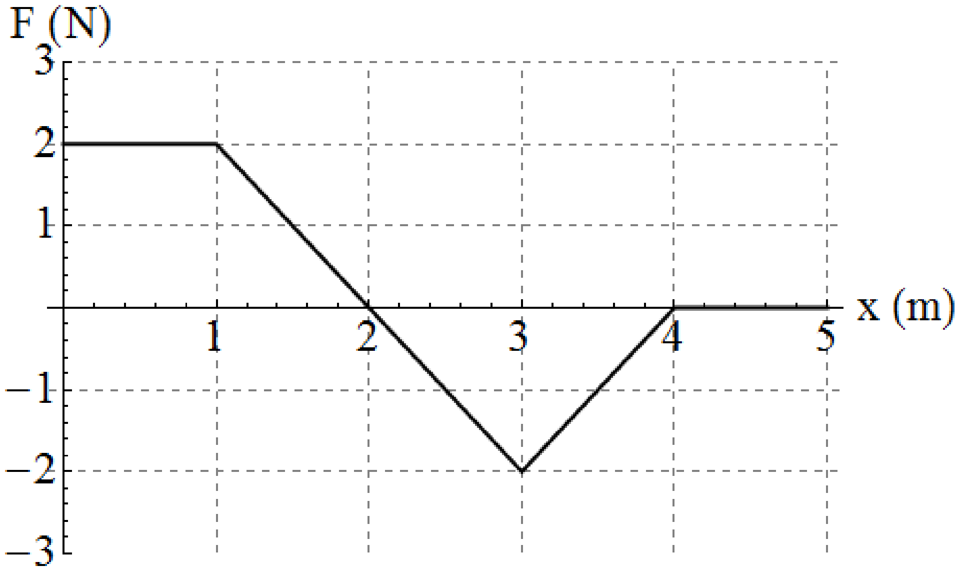
12) Which of the following statements correctly compares the situation before and after the explosion ?

a. Momentum is conserved in the x and y direction. Kinetic energy is not conserved.
b. Neither momentum nor kinetic energy is conserved.
c. Momentum is conserved in the x and y directions. Kinetic energy is also conserved.

13) If the ratio of speeds v_1/v_2 = 3, what is the mass of each of the two right-most fragments m_2?

a. m_2 = 78 kg
b. m_2 = 45 kg
c. m_2 = 90.1 kg
d. m_2 = 13 kg
e. m_2 = 5 kg

The next three questions pertain to the situation described below.



A one-dimensional force, $F(x)$, shown in the graph, acts on a particle that is initially at rest at x = 0.

14) What is the work done by the force on the particle as it moves from x = 0 m to x = 5 m?

a. W = 3 J
b. W = 2 J
c. W = 1 J
d. W = 4 J
e. W = 5 J

15) Which of the following best describes the motion of the particle as it moves from x = 1 m to x = 2 m?

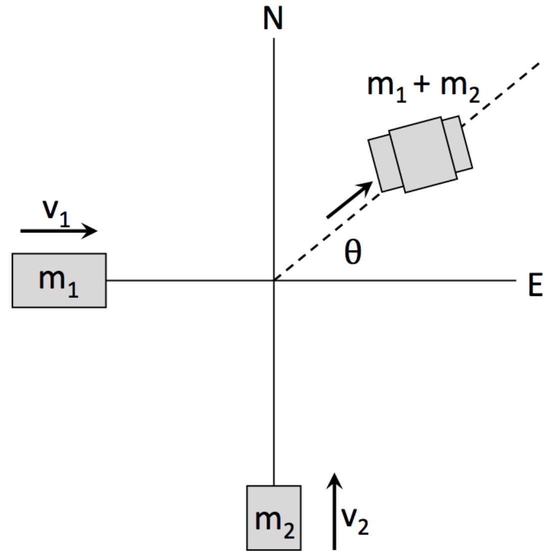
a. It is moving in the $+x$ direction and speeding up.
b. It is moving in the $-x$ direction and speeding up.
c. It is moving in the $-x$ direction and slowing down.
d. It is moving in the $+x$ direction and slowing down.
e. It is moving in the $+x$ direction and its speed is constant.

16) Compare the speed of the particle at x = 1 m to the speed of the particle at x = 3 m.

a. The speed at x = 1 m is less than the speed at x = 3 m
b. The speed at x = 1 m is the same as the speed at x = 3 m
c. The speed at x = 1 m is greater than the speed at x = 3 m

The next three questions pertain to the situation described below.

Two cars collide in an icy intersection. The mass of car 1 is 460 kg and the mass of car 2 is 590 kg. Car 1 was initially traveling east at 13 m/s while car 2 was initially traveling north at 18 m/s. After the cars collide, they stick together and slide off at an angle θ north of east as shown.



17) What is the kinetic energy of the cars as they slide together immediately after the collision ?

a. K = 0 J
b. K = 103181 J
c. K = 70736 J
d. K = 258825 J
e. K = 134450 J

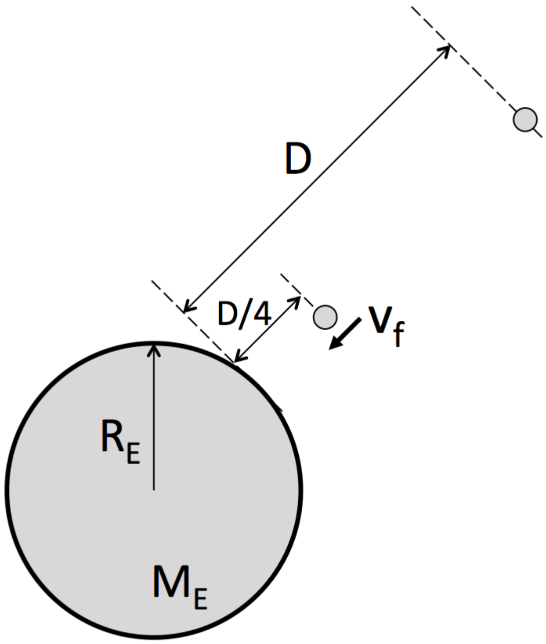
18) Suppose the answer to the previous problem is K. If the initial speed of each car was doubled, how would the new kinetic energy of the cars sliding together immediately after the collision, K_{new}, compare to K?

a. $K_{new} = 4K$
b. $K_{new} = 2K$
c. $K_{new} = \sqrt{2}K$

19) If the initial speed of each car was doubled, how would the angle they slide at after the collision compare to the original problem?

a. The angle would decrease.
b. The angle would stay the same.
c. The angle would increase.

The next two questions pertain to the situation described below.



A rock is released from rest at a distance D = 3×10^7 m above the surface of the Earth as shown in the figure. Useful constants for this problem are the universal gravitational constant G = 6.67×10^{-11} Nm^2/kg^2, the mass of the Earth M_e = 5.97×10^{24} kg, and the radius of the Earth R_e = 6.38×10^6 m.

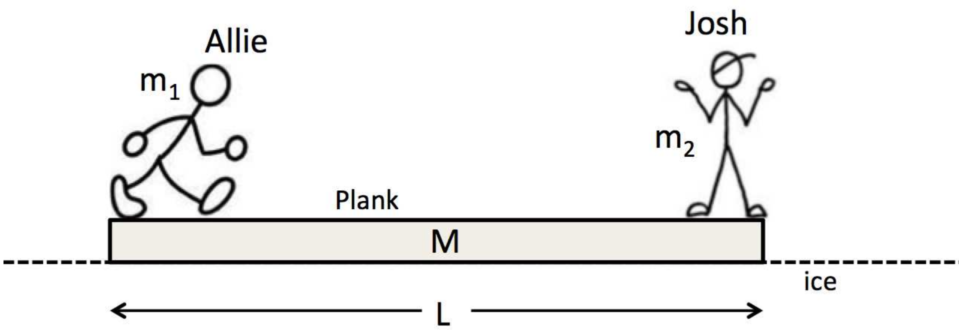
20) What is the speed of the rock, v_f, when it has fallen to a distance D/4 above the surface of the Earth?

a. v_f = 11173 m/s
b. v_f = 4212 m/s
c. v_f = 8924 m/s
d. v_f = 5957 m/s
e. v_f = 21011 m/s

21) Planet Hondo has the same radius as the earth but has a smaller mass. Suppose the same rock were released from the same height D above Hondo. How would be speed of the rock a distance D/4 above the surface compare to the answer you found above?

a. It would be smaller.
b. It would be the same.
c. It would be bigger.

The next three questions pertain to the situation described below.



Allie (mass m_1 = 62 kg) and Josh (mass m_2 = 93 kg) are initially standing still at opposite ends of a plank of length L = 5.6 m and mass M = 21 kg, with Allie at the left end and Josh at the right end. The plank is initially at rest on smooth ice (a frictionless horizontal surface).

22) Suppose Josh stands still while Allie walks all the way to the right end of the plank to give him a hug. What is the displacement of the plank from its initial position as they are hugging? (The +x direction is toward the right in the picture).

a. Δx = 2.24 m
b. Δx = -4.18 m
c. Δx = -1.97 m
d. Δx = -2.24 m
e. Δx = -2.8 m

23) Suppose the mass of the plank was larger but everything else stayed the same. The distance moved by the plank would be:

a. Smaller
b. The same
c. Bigger

24) Suppose instead that Allie walked to the right side of the plank to meet Josh, and then that Josh and Allie walked together back to the left side of the plank. Which of the following statements best describes the movement of the plank?

a. The plank does not move.
b. The plank moves to the right a distance D_R and then to the left a distance D_L, where $D_R < D_L$
c. The plank moves to the left a distance D_L and then to the right a distance D_R, where $D_L > D_R$
d. The plank moves to the left a distance D_L and then to the right a distance D_R, where $D_L < D_R$
e. The plank moves to the right a distance D_R and then to the left a distance D_L, where $D_R > D_L$

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 $G = 6.67\text{x}10^{-11}\ Nm^2/kg^2$)
$\mathbf{F}_{spring} = -k\,\mathbf{\Delta x}$

Friction
$f = \mu_k N$ (kinetic)
$f \leq \mu_S N$ (static)

Work & Kinetic energy
$W = \int \mathbf{F}\cdot\mathbf{dl}$
$W = \mathbf{F}\cdot\mathbf{\Delta r} = F\,\Delta r\,\cos\theta$
(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)

In addition, if the collision is elastic:
* $E_{before} = E_{after}$
* *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
$s = R\theta$, $v = R\omega$, $a = R\alpha$
$\theta = \theta_0 + \omega_0 t + {}^1/_2\alpha t^2$
$\omega = \omega_0 + \alpha t$
$\omega^2 = \omega_0^2 + 2\alpha\Delta\theta$

Rotational Dynamics
$I = \Sigma m_i r_i^2$
$I_{parallel} = I_{CM} + MD^2$
$I_{disk} = I_{cylinder} = {}^1/_2MR^2$
$I_{hoop} = MR^2$
$I_{solid\text{-}sphere} = {}^2/_5MR^2$
$I_{spherical\ shell} = {}^2/_3MR^2$
$I_{rod\text{-}cm} = {}^1/_{12}ML^2$
$I_{rod\text{-}end} = {}^1/_3\,ML^2$
$\tau = I\alpha$ (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:
$y(x,t) = A\cos(kx - \omega t)$
$k = 2\pi/\lambda$, $\omega = 2\pi f = 2\pi/T$
$v = \lambda f = \omega/k$

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

$$A_1v_1 = A_2v_2$$

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

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

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