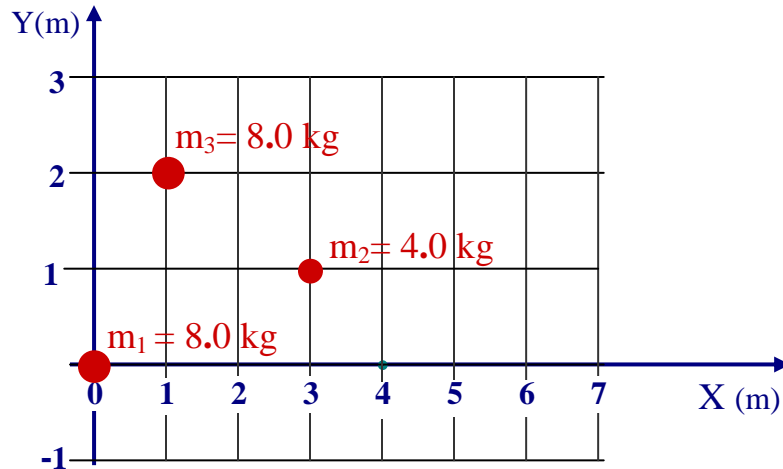


Exam #3Monday July 13th, 2009**PHYSICS 211**

NAME _____

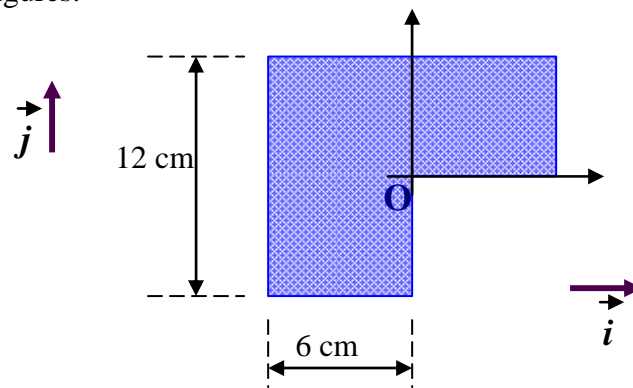
Please write down your name also on
the back page of this exam

1. 1A The figure shows a three particle system with masses $m_1 = 8.0$ kg, $m_2 = 4$ kg, and $m_3 = 8$ kg. What are the coordinates of the center of mass?



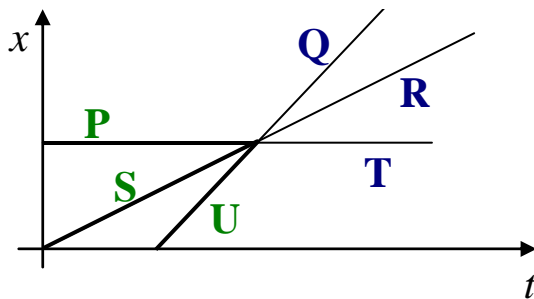
ANSWER: $\vec{R}_{CM} = 1 \text{ m } \vec{i} + 1 \text{ m } \vec{j}$

- 1B Find the coordinates of the "Center of Mass" of the homogeneous thin plate shown in the figures.



ANSWER: $\vec{R}_{CM} = -1 \text{ cm } \vec{i} + 1 \text{ cm } \vec{j}$

2. **2A** Two bodies have undergone an elastic one-dimensional collision along the x -axis. The figure shows the position vs time for those bodies and for the center of mass.



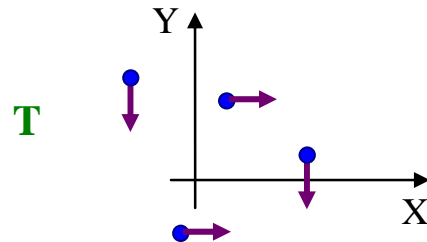
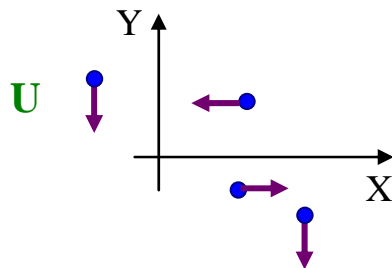
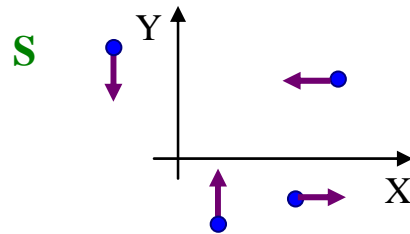
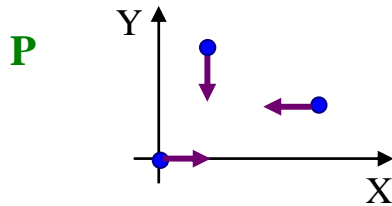
Which segments correspond to the motion of the center of mass

ANSWER S and R

If we assume that the mass of the particles are equal, indicate the segments corresponding to the motion of the particle that was moving faster before the collision.

ANSWER U and T

- 2B** The figure below shows groups of identical particles that move parallel to either the x -axis or the y -axis and at identical speeds. Rank the groups according to the speed of the center of mass, greatest first.

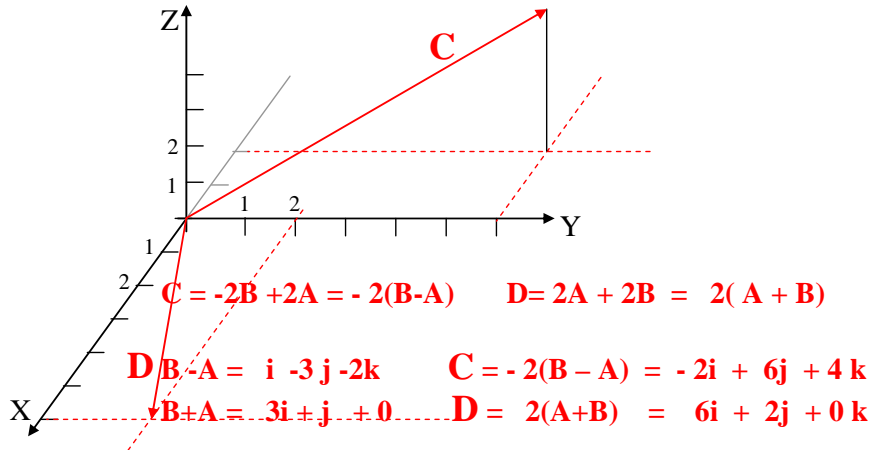


ANSWER T,U,P,S

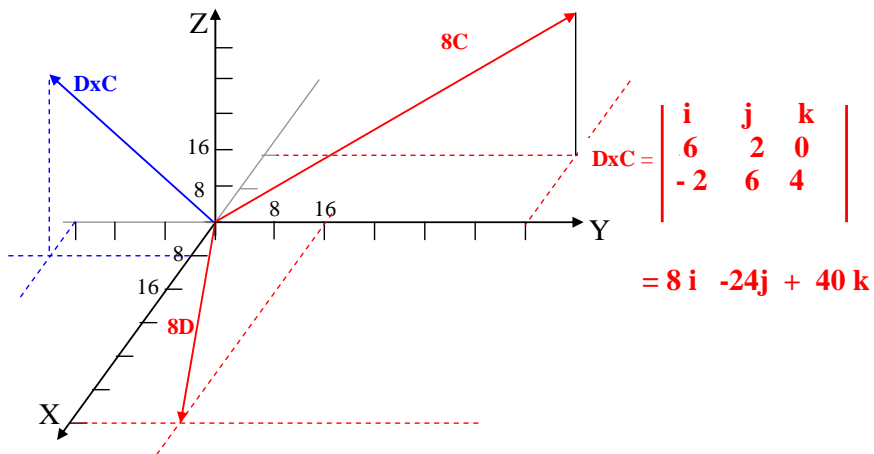
3. Given the vectors $\vec{A} = 1\vec{i} + 2\vec{j} + 1\vec{k}$ and $\vec{B} = 2\vec{i} - 1\vec{j} - 1\vec{k}$

3A. Calculate and graph the vectors \vec{C} and \vec{D} , where

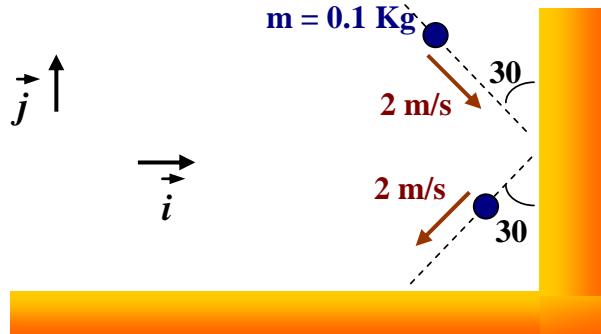
$$\vec{C} = (\vec{B} + \vec{A}) - (3\vec{B} - \vec{A}) \quad \text{and} \quad \vec{D} = (4\vec{A} + \vec{B}) - (2\vec{A} - \vec{B})$$



3B. Calculate and graph the vector $\vec{D} \times \vec{C}$, where \times stands for the vector product

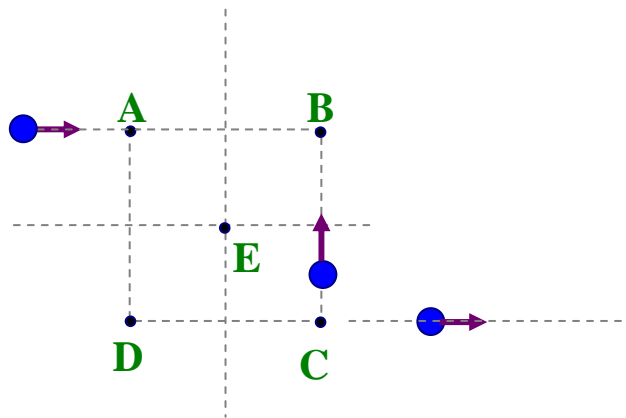


4. **4A** A ball of mass $m = 0.1 \text{ Kg}$ approaches a wall with a speed of 2 m/s . The incidence direction makes 30 degrees with the vertical direction as shown in the figure. After bouncing from the wall the ball also has a speed of 2 m/s . The change of the LINEAR MOMENTUM of the particle is:



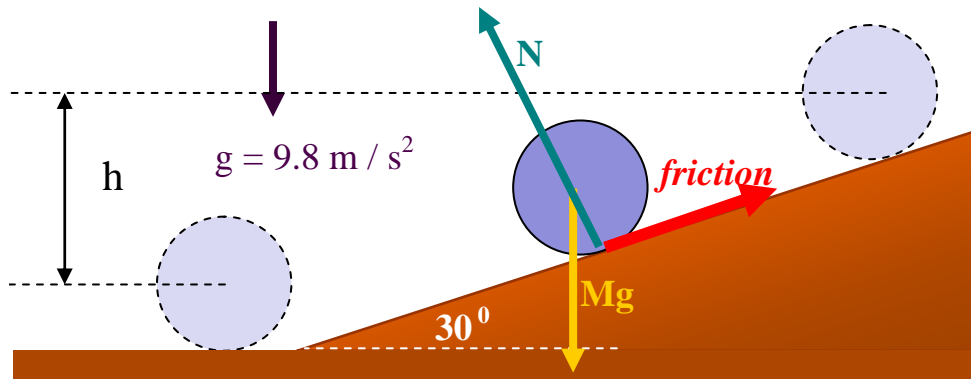
ANSWER: $\Delta \vec{P} = \underline{-0.2 \text{ Kg m/s } \hat{i} + 0 \hat{j}}$

- 4B** The figure shows three particles of the same mass and the same constant speed. The arrows in the figure indicate the corresponding velocity vectors. You are asked to evaluate the vector angular momentum of the three-particle system with respect to the five fixed points indicated in the figure, one at the time. The five points A, B, C, and D, form a square with point E at the center. Rank the magnitude of the angular momentum L_A, L_B, L_C, L_D, L_E ; greatest first.



ANSWER: $A > B=C > E > D=0$

- 5 A uniform ball of mass $M = 6.00$ kg and radius $R = 0.30$ m, rolls without slipping down a ramp at angle $\theta = 30.0^\circ$. The ball starts from rest and descends a vertical height $h = 1.20$ m



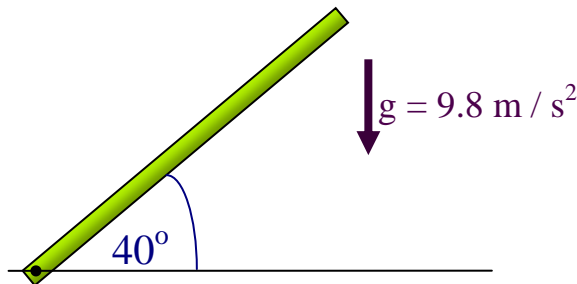
5A Draw all the forces acting on the ball (use the ball at the center in the graph above.)

5B Calculate the velocity of the center of mass when the ball is at the bottom (in m/s).

- a) 4.1 b) 7.3 c) 2.6 d) 1.8 e) NA
-

6. A thin uniform rod of length $L = 2.0$ m and $M = 0.75$ kg can pivot about a horizontal, frictionless pin through one end.

6A. Calculate the moment of inertia of the bar with respect to the pivot axis.

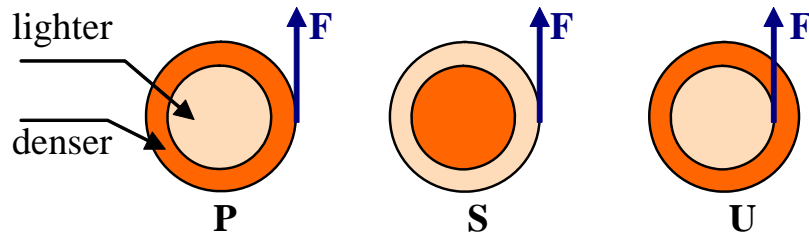


ANSWER _____ 1 kg m² _____

6B. It is released from rest at angle $q = 40^\circ$ above the horizontal. Use the principle of conservation of mechanical energy to determine the angular speed of the rod as it passes through the horizontal position.

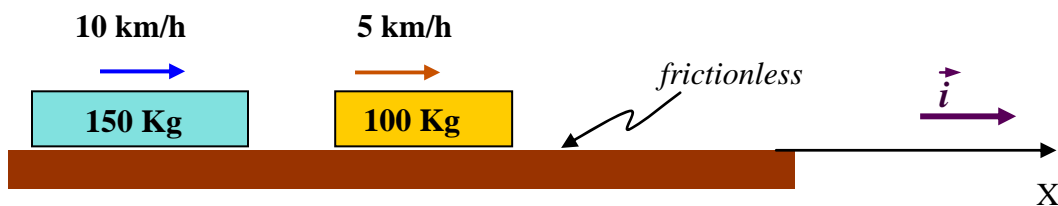
ANSWER _____ 3.1 rad/s _____

7. The figure shows three flat disks of the same radius and the same total mass, which can rotate about their centers like merry-go-grounds. Each disk consists of the same two materials, one denser than the other. In disks 1 and 3, the denser material forms the outer half of the disk area. In disk-2, it forms the inner half of the disk area.



- 7A Rank the disks according to the torque, evaluated with respect to the disk center; greatest first.
 a) P, U, S b) S, U, P c) P, S=U **d) P=S, U** e) NA
- 7B Rank the disks according to the momentum of inertia I , evaluated with respect to the disk center; greatest first.
 a) S, P=U **b) P=U, S** c) P, S, U d) S, U, P e) NA

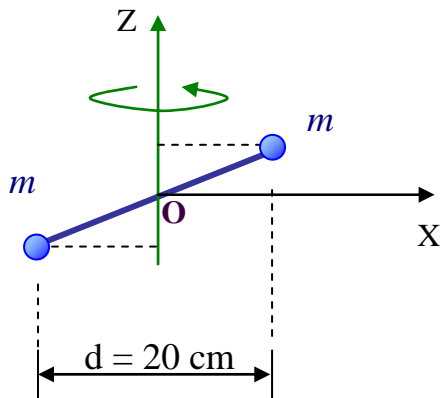
- 8 A 150.0 Kg block travels with speed of 10.0 km/h and another block of 100.0 Kg. traveling at 5.0 km/h, as shown in the figure. The blocks undergo an elastic collision.



- 8A The velocity of the center of mass after the collision is (in km/h):
 a) 7.5 b) 6.0 **c) 8.0** d) 9.0 e) NA
- 8B After the collision, the velocity of 150.0 Kg mass measured from a reference traveling with the center of mass is (in km/h.)
a) -2.0 b) 5.8 c) -3.1 d) 0 e) NA

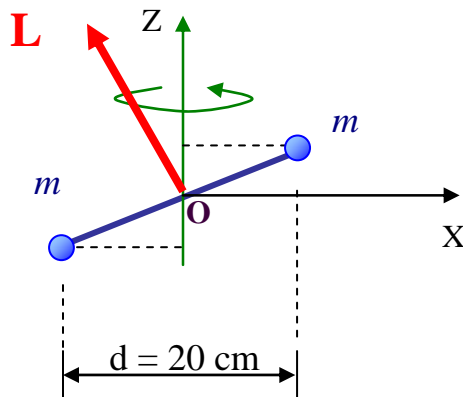
9 A couple of small balls, each of mass $m = 0.5 \text{ kg}$, are joined rigidly by a massless rod which rotates around the z -axis. The rod makes an angle of 70° with the z -axis. The figure below shows the position of the system at $t=0$, when the bar happens to be in the XZ plane

9A What is the momentum of inertia with respect to the z -axis passing through the center of mass?



$$\begin{aligned}
 I_{\text{CM}} &= m (d/2)^2 + m (d/2)^2 \\
 &= m d^2 / 2 \\
 &= (0.5) (0.5 \text{ kg}) (0.2 \text{ m})^2 \\
 &= 0.01 \text{ kg m}^2
 \end{aligned}$$

9B The figure above shows the position of the system at $t=0$, when the bar happens to be in the XZ plane. Draw the vector ANGULAR MOMENTUM of the system at $t=0$.



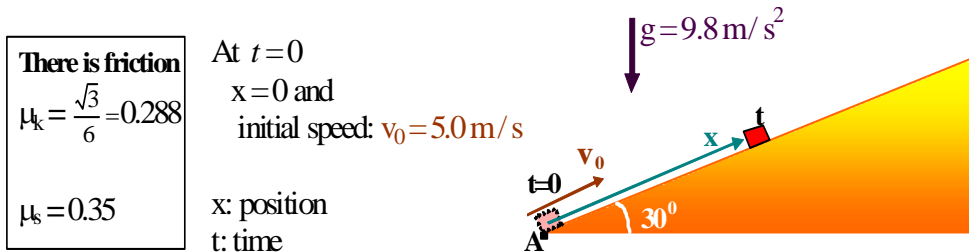
10 A block of mass $m = 0.8 \text{ Kg}$ slides up a rough ramp. At $t=0$ the block is at A (the bottom of the ramp) and its initial speed is 5.0 m/s . When the block reaches its highest position

10A what is the distance it has traveled along the ramp?

- a) 4.5 m b) 3.1 m c) 0.5 m **d) 1.7 m** e) NA

10B what is the work done by the gravitational force?

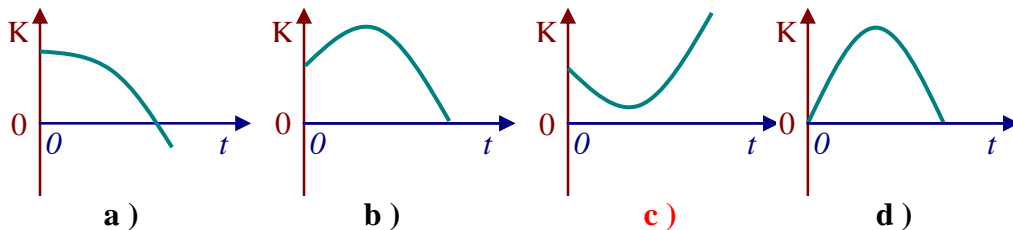
- a) -6.6 J** b) -12 J c) 3.1 J **d) -8.3 J** e) NA



BONUS QUESTIONS

B1. (5 points)

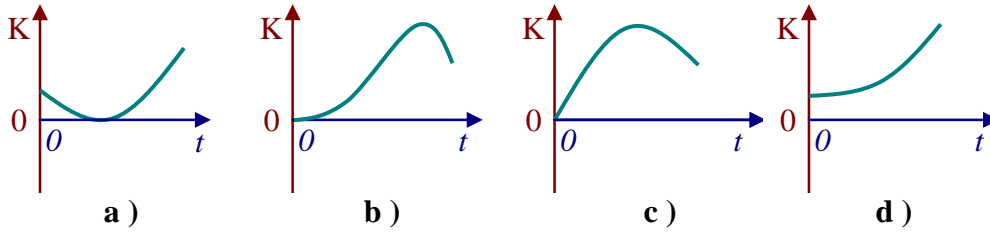
At $t=0$ a stone is launched or dropped from the edge of a cliff. The graphs show only the first instants of the motion. Circle the graph(s) that could possibly show how the kinetic energy of the glob changes during its flight.



e) All the graphs above are incorrect

B2. (5 points)

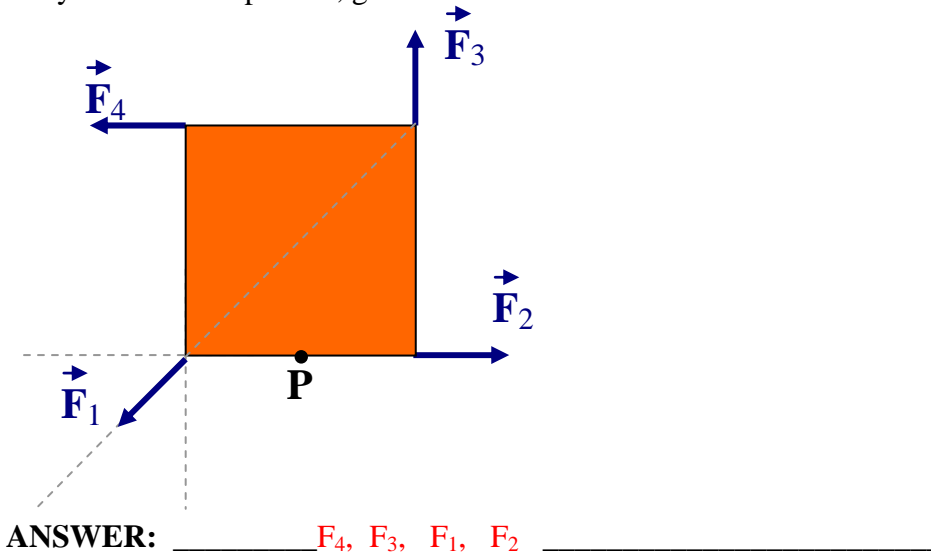
A stone is dropped from the edge of a cliff at $t=0$. Circle the graph(s) that could possibly show how the kinetic energy of the glob changes during its flight.



e) All the graphs above are incorrect

B3 (5 points)

In the overhead view of the figure at the right side, four forces of the same magnitude act on a merry-go-around for the strange; it is a square, of side equal to 2 m, that can rotate about point "P" at mid-length along one of the edges. Rank the forces acting on the square according to the magnitude of the torque they create about point P, greatest first.



B4 (5 points)

TRANSLATIONAL MOTION and FREE BODY DIAGRAM. The coefficient of kinetic friction between the block and the ramp is 0.20. First the block moves up with an acceleration of magnitude a_{up} . Then, after momentarily stopping, it moves down with an acceleration of magnitude a_{down} . Which statement given below is correct:



- a) $a_{\text{up}} > a_{\text{down}}$
 - b) $a_{\text{up}} < a_{\text{down}}$
 - c) $a_{\text{up}} = a_{\text{down}}$
 - d) The value of a_{up} depends on the mass of the block.
 - e) NA
-

Helpful formulas

$$\text{Average velocity} = \Delta \mathbf{x} / \Delta t$$

$$\text{instantaneous velocity } \mathbf{v} = d \mathbf{x} / dt$$

$$\text{Average acceleration} = \Delta \mathbf{v} / \Delta t$$

$$\text{instantaneous acceleration } \mathbf{a} = d \mathbf{v} / dt$$

Motion under constant acceleration “a”

$$v = v_o + a t$$

$$x - x_o = v_o t + (1/2) a t^2$$

$$v^2 = v_o^2 + 2 a (x - x_o)$$

Free fall

$$v_y = v_{oy} - g t$$

$$g = 9.8 \text{ m/s}^2$$

$$y - y_o = v_{oy} t - (1/2) g t^2$$

$$x - x_o = v_{ox} t$$

$$g = 32 \text{ ft/s}^2$$

$$v_y^2 = v_{oy}^2 - 2 g (y - y_o)$$

Projectile motion

$$x = x_o + (v_o \cos \theta) t$$

$$y = y_o + (v_o \sin \theta) t - (1/2) g t^2$$

$$\text{Range } R = (v_o^2 / g) \sin 2\theta$$

$$\text{Uniform circular motion } \quad \mathbf{a} = v^2 / R$$

$$\text{Newton's second law } \quad \mathbf{F} = m \mathbf{a}$$

$$\text{Work/Kinetic-energy theorem } \quad \Delta K = W_{\text{total}}$$

$$\text{Rotational motion } \quad v = \omega R$$

$$\text{Rotational kinetic energy } \quad K_{\text{rot}} = (1/2) I \omega^2$$

Momentum of inertia $I = \sum_i m_i r_i^2$

Solid sphere of radius “R”: $I_{\text{CM}} = (2/5) M R^2$ (with respect to an axis passing through the CM)

Thin bar of length “L”: $I_{\text{CM}} = (1/12) M L^2$ (with respect to an axis passing through the CM and perpendicular to the bar.)

Angular momentum $\mathbf{L} = \mathbf{r} \times \mathbf{p} = m \mathbf{r} \times \mathbf{v}$
