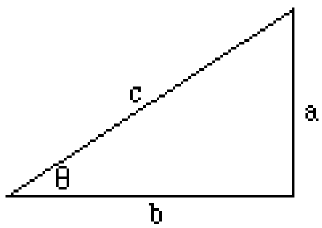
SAMPLE QUIZ 4

This is a closed book, closed notes quiz. Calculators are permitted. The **ONLY** formulas that may be used are those given below. Define all symbols and justify all mathematical expressions used. Make sure to state all of the assumptions used to solve a problem. Credit is given only for a logical and complete solution that is clearly communicated. Partial credit will be given for a well communicated problem solving strategy based on correct physics such as the strategy illustrated in the Competent Problem Solver. MAKE SURE YOUR NAME AND ID # IS ON EACH PAGE!! Each problem is worth 25 points: In the context of a unified solution, a useful picture, defining the question, and giving your approach is worth 6 points; a complete physics diagram defining the relevant quantities, identifying the target quantity, and specifying the relevant equations is worth 6 points; planning the solution by constructing the mathematics leading to an algebraic answer and checking the units of that answer is worth 7 points; calculating a numerical value with correct units is worth 3 points; and evaluating the validity of the answer is worth 3 points. The multiple choice questions are worth 2.5 points each for a total of 25 points.

Useful Mathematical Relationships:



For a right triangle: $\sin\theta = \frac{a}{c}$, $\cos\theta = \frac{b}{c}$, $\tan\theta = \frac{a}{b}$,

$a^2 + b^2 = c^2$, $\sin^2\theta + \cos^2\theta = 1$

For a circle: $C = 2\pi R$, $A = \pi R^2$

For a sphere: $A = 4\pi R^2$, $V = \frac{4}{3}\pi R^3$

If $Ax^2 + Bx + C = 0$, then $x = \dfrac{-B \pm \sqrt{B^2 - 4AC}}{2A}$

$\frac{d(z^n)}{dz} = nz^{n-1}$, $\frac{d(\cos z)}{dz} = -\sin z$, $\frac{d(\sin z)}{dz} = \cos z$, $\frac{df(z)}{dt} = \frac{df(z)}{dz}\frac{dz}{dt}$, $\int\left(\frac{dw}{dz}\right)dz = w$,

$\frac{d}{dz}\int w\,dz = w$, $\int z^n dz = \frac{z^{n+1}}{n+1}\ (n \neq -1)$

Fundamental Concepts and Principles:

$\bar{v}_x = \frac{\Delta x}{\Delta t}$	$\bar{s} = \frac{\text{dist}}{\Delta t}$	$\bar{a}_x = \frac{\Delta v_x}{\Delta t}$	$\theta = \frac{\Delta C}{r}$	$\bar{\omega} = \frac{\Delta\theta}{\Delta t}$	$\bar{\alpha} = \frac{\Delta\bar{\omega}}{\Delta t}$
$v_x = \frac{dx}{dt}$	$s = \frac{dr}{dt}$	$a_x = \frac{dv_x}{dt}$	$\omega = \frac{d\theta}{dt} = \frac{v_t}{r}$	$\alpha = \frac{d\omega}{dt} = \frac{a_t}{r}$	$\sum\vec{F} = m\vec{a}$
$\tau = rF_t$	$\sum\vec{\tau} = I\vec{\alpha}$	$W = \int_{\text{path}}\vec{F}\bullet d\vec{\ell}$	$KE = \frac{1}{2}mv^2$	$E_f - E_i = \Delta E_{\text{transfer}}$	$\vec{p} = m\vec{v}$
$\vec{p}_f - \vec{p}_i = \Delta\vec{p}_{\text{transfer}}$	$\vec{p}_{\text{transfer}} = \int\vec{F}dt$	$\vec{r}_{\text{com}} = \frac{\sum m_i\vec{r}_i}{\sum m_i} = \frac{\int\vec{r}dm}{\int dm}$		$I = \sum m_i r_i^2 = \int r^2 dm$	$\vec{L} = I\vec{\omega}$
$\vec{L}_f - \vec{L}_i = \Delta\vec{L}_{\text{transfer}}$	$\vec{L} = \vec{r}\times\vec{p}$	$\vec{L}_{\text{transfer}} = \int\vec{\tau}dt$			

Under Certain Conditions:

$x_f = \frac{1}{2}a_x(\Delta t)^2 + v_{ox}\Delta t + x_o$	$F = \mu_k F_N$	$F \le \mu_s F_N$	$F = k\Delta x$	$KE = \frac{1}{2}I\omega^2$	$PE = mgy$	$PE = \frac{1}{2}kx^2$
$\theta_f = \frac{1}{2}\alpha(\Delta t)^2 + \omega_o\Delta t + \theta_o$	$a = \frac{v^2}{r}$	$I = I_{cm} + Md^2$	$v_{cm} = r\omega$			

Useful constants: 1 mile = 5280 ft, $g = 9.8\ m/s^2 = 32\ ft/s^2$

Problems

1. You have been hired as a stunt advisor for a movie to be shot in Minnesota during the winter. The villain attempts to crush the hero by releasing a large sewer pipe from rest on a boat ramp. It rolls down the ramp and at the bottom of the ramp it encounters the horizontal, slick ice of a frozen stream. Having crossed the frozen stream, the pipe starts up a second ramp that is covered with slick ice. The hero is standing at the top of this ramp. The director wants the sewer pipe to almost reach her. Your assistant has measured the maximum height (above the frozen stream) that the center of the sewer pipe can reach. He has also measured the mass and radius of the pipe and the different angles that the two ramps make with the horizontal. At what height do you tell the crew to place the center of the sewer pipe before releasing it on the first ramp?

2. You are helping to design the opening ceremony for the next winter Olympics. One of the choreographers envisions dancers running, then sliding out onto the ice and each grabbing a large ring (the symbol of the Olympics) that has about the same weight as a dancer. The ring is held horizontally at shoulder height by a vertical pole stuck into the ice. The pole is attached to the ring on its circumference so that the ring can rotate horizontally around the pole. The plan is to have a dancer grab the ring at a point on the opposite side from where the pole is attached and, holding on, slide around the pole in a circle. You have been assigned the task of determining the minimum speed that the dancer must have before grabbing the ring in terms of the radius of the ring (r), the mass of the ring (M), the mass of the dancer (m), and the constant frictional force (f) between the dancer's shoes and the ice. The choreographer wants the dancer and ring to go around the pole at least twice. The dancer moves tangent to the ring just before grabbing it.

3. You are part of a team evaluating a design for a new bridge across the St. Croix River. To save money a very simple construction technique has been proposed. The bridge will be a flat horizontal structure hanging at each end from a large cable. The other end of each cable is supported by two high towers on either side of the river. Because of the different geology of the two banks of the river, the towers are different distances from the bridge. This requires each cable to be attached to the bridge at a different angle. The design specifications give the two different angles that the cables are attached to each end of the bridge, the weight of the bridge, and its length. To begin your structural analysis, you need to find the position of the center of mass of the non-uniform bridge.

Part III - Conceptual Questions

1. A steel ball **rolls** without slipping down a ramp starting from rest and an identical steel ball, also starting from rest at the same place, **slides** down an identical but frictionless ramp. At the bottom of the ramp
    - (a) the sliding ball is going faster than the rolling ball.
    - (b) the rolling ball is going faster than the sliding ball.
    - (c) both balls are going with the same speed.
    - (d) the answer to this question depends on the length of the ramp.
    - (e) the answer to this question depends on the height of the ramp.

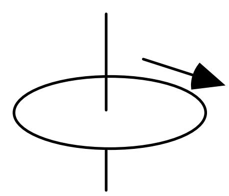
2. A uniform plank of wood is supported on two scales as shown. Which of the following statements is **true**?

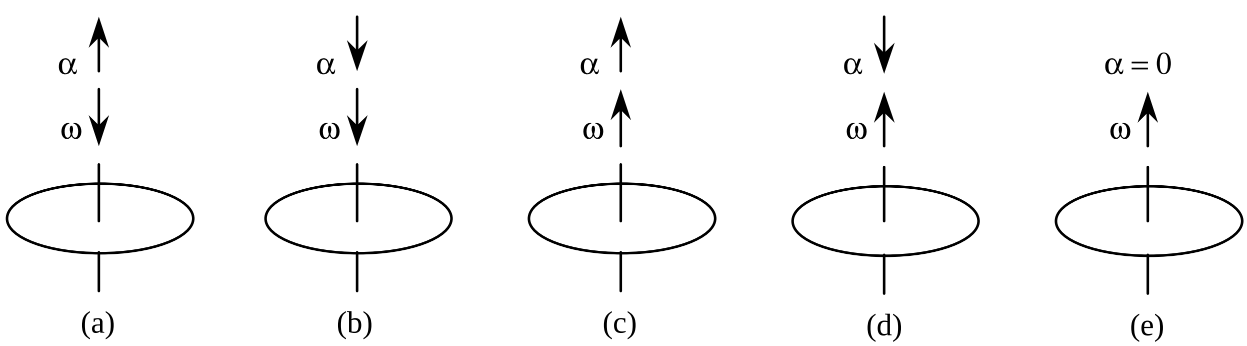
   (a) A exerts both a greater force and a greater torque about the center of the plank than B.
   (b) B exerts both a greater force and a greater torque about the center of the board than A.
   (c) B exerts a greater force than A but both exert the same torque about the center of the plank.
   (d) A exerts a greater force than B but both exert the same torque about the center of the plank.
   (e) Both A and B exert the same force and the same torque about the center of the plank.

3. A projectile moving to the left explodes at the top if its trajectory and breaks into two equal parts. Just after the explosion, one part has zero velocity and then drops straight down. What is the direction of the other part of the projectile **just after the explosion**?

   (a) Straight up.
   (b) To the right.
   (c) Up and to the left.
   (d) Down and to the right.
   (e) To the left.

4. The figure depicts a disk that is rotating in the clockwise direction. When the power is turned off, the disk gradually **slows down** and stops. Which figure below shows the directions of the angular velocity vector (ω) and the angular acceleration vector (α) during this slowing down process?

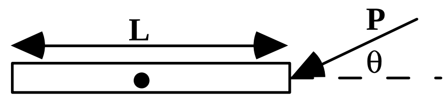




5. A ring **rolls without slipping** across the floor. The ring's rotational kinetic energy is

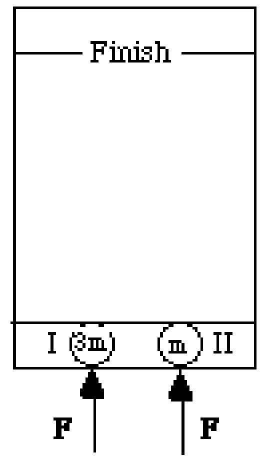
   (a) larger than its translational kinetic energy.
   (b) smaller than its translational kinetic energy.
   (c) equal to its translational kinetic energy.
   (d) independent of its mass.
   (e) independent of its center of mass motion.

6. You push on a bar of length L as shown in the picture. The bar is pivoted about an **axis through its center** as shown. The torque you are exerting on the bar is



(a) PL
(b) P(L/2)
(c) P(L/2) sin θ
(d) P(L/2) cos θ
(e) P(L/2) tan θ

The figure depicts two pucks on a frictionless table. Puck I is three times more massive than puck II. Starting from rest, both pucks are simultaneously and continuously pushed across the table by **equal** forces. The next two questions refer to this situation.



7. Which puck will have the **greater energy** at the instant the first puck reaches the finish line?
(a) puck I
(b) puck II
(c) They will both have the same energy.
(d) Too little information to answer.

8. Which puck will have the **greater momentum** at the instant the first puck reaches the finish line?
(a) puck I
(b) puck II
(c) They will both have the same momentum.
(d) Too little information to answer.

9. An elevator is being pulled up straight up on a cable at **a constant speed**. The elevator only has contact with the cable. Ignoring any effects due to the air:
(a) the tension of the cable is greater than the weight of the elevator.
(b) the tension of the cable is less than the weight of the elevator.
(c) the tension of the cable is equal to the weight of the elevator.
(d) which is greater depends on how fast the elevator is going.
(e) there is no connection between the tension of the cable and the weight of the elevator.

10. The space shuttle in a circular orbit around the earth has a gravitational acceleration of about 0.95 g. The torque exerted on the space shuttle **by the Earth** is

(a) 9.5 times its mass times the distance of the shuttle from the Earth.
(b) toward the Earth
(c) tangential to the shuttle's orbit
(d) perpendicular to the plane of the shuttle's orbit
(e) zero