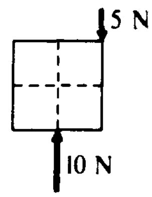
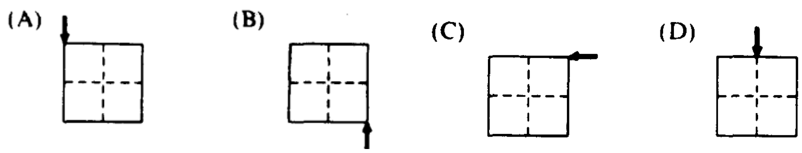
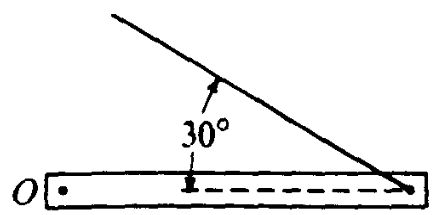
AP Physics – Unit 7 Toque and Rotational Motion
Wkst – PreExam – MC – Unit 7

SECTION A – Torque and Statics

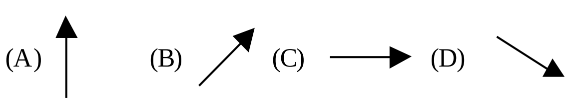


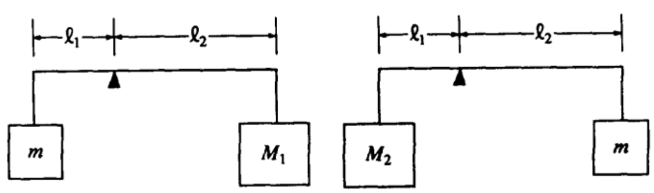
1. A square piece of plywood on a horizontal tabletop is subjected to the two horizontal forces shown above. Where should a third force of magnitude 5 newtons be applied to put the piece of plywood into equilibrium?





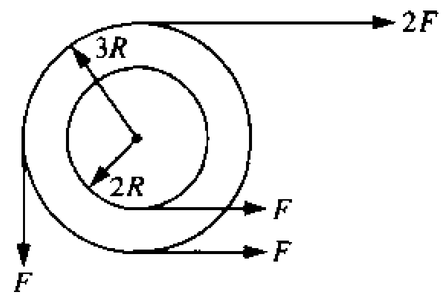
2. A uniform rigid bar of weight W is supported in a horizontal orientation as shown above by a rope that makes a 30° angle with the horizontal. The force exerted on the bar at point O, where it is pivoted, is best represented by a vector whose direction is which of the following?





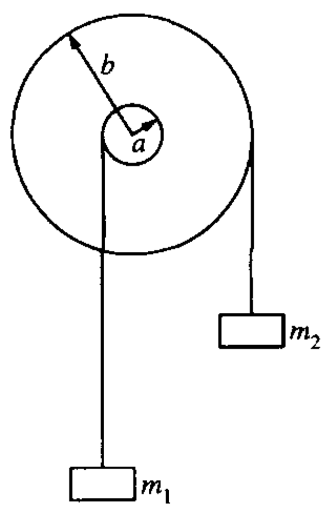
3. A rod of negligible mass is pivoted at a point that is off-center, so that length l_1 is different from length l_2. The figures above show two cases in which masses are suspended from the ends of the rod. In each case the unknown mass m is balanced by a known mass, M_1 or M_2, so that the rod remains horizontal. What is the value of m in terms of the known masses?

(A) $M_1 + M_2$ (B) $\frac{1}{2}(M_1 + M_2)$ (C) $M_1 M_2$ (D) $\sqrt{M_1 M_2}$



4. A system of two wheels fixed to each other is free to rotate about a frictionless axis through the common center of the wheels and perpendicular to the page. Four forces are exerted tangentially to the rims of the wheels, as shown above. The magnitude of the net torque on the system about the axis is

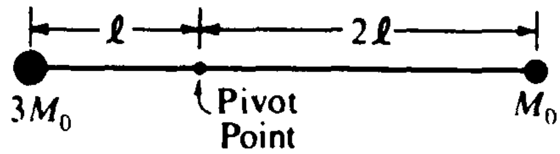
(A) FR (B) 2FR (C) 5FR (D) 14FR



5. For the wheel-and-axle system shown above, which of the following expresses the condition required for the system to be in static equilibrium?
(A) $m_1 = m_2$ (B) $am_1 = bm_2$ (C) $am_2 = bm_1$ (D) $a^2m_l = b^2m^2$

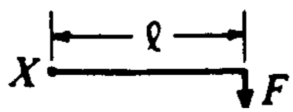
SECTION B – Rotational Kinematics and Dynamics

1. A uniform stick has length L. The moment of inertia about the center of the stick is I_o. A particle of mass M is attached to one end of the stick. The moment of inertia of the combined system about the center of the stick is
(A) $I_0 + \frac{1}{4}ML^2$ (B) $I_0 + \frac{1}{2}ML^2$ (C) $I_0 + \frac{3}{4}ML^2$ (D) $I_0 + ML^2$

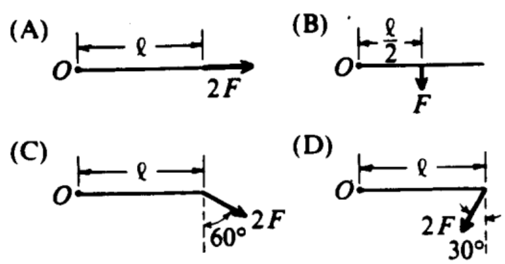


2. A light rigid rod with masses attached to its ends is pivoted about a horizontal axis as shown above. When released from rest in a horizontal orientation, the rod begins to rotate with an angular acceleration of magnitude

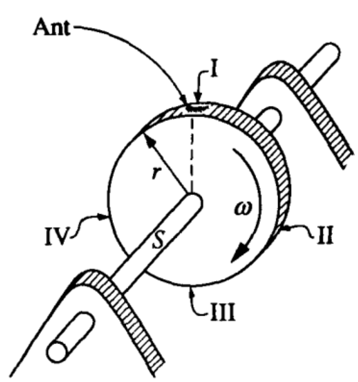
(A) $\frac{g}{7l}$ (B) $\frac{g}{5l}$ (C) $\frac{g}{4l}$ (D) $\frac{5g}{7l}$



3. In which of the following diagrams is the torque about point O equal in magnitude to the torque about point X in the diagram above? (All forces lie in the plane of the paper.)



Questions 4-5



An ant of mass m clings to the rim of a flywheel of radius r, as shown above. The flywheel rotates clockwise on a horizontal shaft S with constant angular velocity ω. As the wheel rotates, the ant revolves past the stationary points I, II, III, and IV. The ant can adhere to the wheel with a force much greater than its own weight.

4. It will be most difficult for the ant to adhere to the wheel as it revolves past which of the four points?
(A) I (B) II (C) III (D) IV

5. What is the magnitude of the minimum adhesion force necessary for the ant to stay on the flywheel at point III?
(A) mg (B) $m\omega^2r$ (C) $m\omega^2r$ - mg (D) $m\omega^2r$ + mg

6. A turntable that is initially at rest is set in motion with a constant angular acceleration α. What is the angular velocity of the turntable after it has made one complete revolution?

(A) $\sqrt{2\alpha}$ (B) $\sqrt{2\pi\alpha}$ (C) $\sqrt{4\pi\alpha}$ (D) $4\pi\alpha$

Questions 7-8

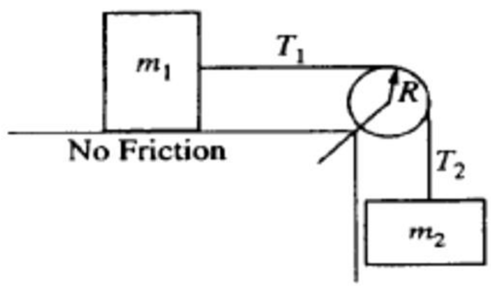
A wheel with rotational inertia *I* is mounted on a fixed, frictionless axle. The angular speed ω of the wheel is increased from zero to ω_f in a time interval T.

7. What is the average net torque on the wheel during this time interval?

(A) $\frac{\omega_f}{T}$ (B) $\frac{I\omega_f^2}{T}$ (C) $\frac{I\omega_f}{T^2}$ (D) $\frac{I\omega_f}{T}$

8. **SKIP** -What is the average power input to the wheel during this time interval?

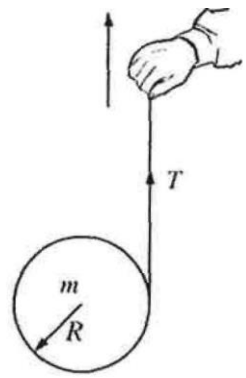
(A) $\frac{I\omega_f}{2T}$ (B) $\frac{I\omega_f^2}{2T}$ (C) $\frac{I\omega_f^2}{2T^2}$ (D) $\frac{I^2\omega_f}{2T^2}$



9. Two blocks are joined by a light string that passes over the pulley shown above, which has radius *R* and moment of inertia *I* about its center. T_1 and T_2 are the tensions in the string on either side of the pulley and α is the angular acceleration of the pulley. Which of the following equations best describes the pulley's rotational motion during the time the blocks accelerate?

(A) $m_2gR = I\alpha$ (B) $T_2R = I\alpha$ (C) $(T_2 - T_1)R = I\alpha$ (D) $(m_2 - m_1)gR = I\alpha$

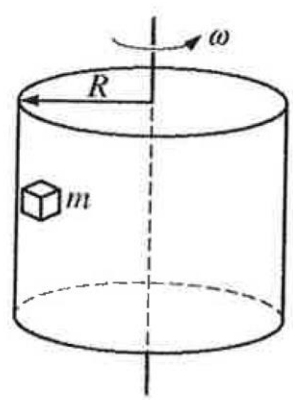
Questions 10-11



A solid cylinder of mass *m* and radius *R* has a string wound around it. A person holding the string pulls it vertically upward, as shown above, such that the cylinder is suspended in midair for a brief time interval Δt and its center of mass does not move. The tension in the string is *T*, and the rotational inertia of the cylinder about its axis is $\frac{1}{2}MR^2$

10. the net force on the cylinder during the time interval Δt is
(A) mg (B) $T - mgR$ (C) $mgR - T$ (D) zero

11. The linear acceleration of the person's hand during the time interval Δt is
(A) $\frac{T - mg}{m}$ (B) $2g$ (C) $\frac{g}{2}$ (D) $\frac{T}{m}$



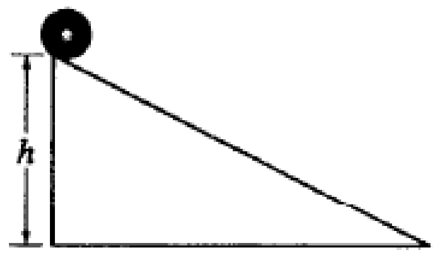
12. A block of mass *m* is placed against the inner wall of a hollow cylinder of radius *R* that rotates about a vertical axis with a constant angular velocity ω, as shown above. In order for friction to prevent the mass from sliding down the wall, the coefficient of static friction μ between the mass and the wall must satisfy which of the following inequalities?
(A) μ ³ $\frac{g}{W^2 R}$ (B) μ ³ $\frac{W^2 R}{g}$ (C) μ £ $\frac{g}{W^2 R}$ (D) μ £ $\frac{W^2 R}{g}$

SECTION C – Rolling

1. A bowling ball of mass M and radius R. whose moment of inertia about its center is $(2/5)MR^2$, rolls without slipping along a level surface at speed v. The maximum vertical height to which it can roll if it ascends an incline is

   (A) $\frac{v^2}{5g}$ (B) $\frac{2v^2}{5g}$ (C) $\frac{v^2}{2g}$ (D) $\frac{7v^2}{10g}$

Questions 2-3



A sphere of mass M, radius r, and rotational inertia I is released from rest at the top of an inclined plane of height h as shown above.

2. If the plane is frictionless, what is the speed v_{cm}, of the center of mass of the sphere at the bottom of the incline?

   (A) $\sqrt{2gh}$ (B) $\frac{2Mghr^2}{I}$ (C) $\sqrt{\frac{2Mghr^2}{I}}$ (D) $\sqrt{\frac{2Mghr^2}{I+Mr^2}}$

3. If the plane has friction so that the sphere rolls without slipping, what is the speed v_{cm} of the center of mass at the bottom of the incline?

   (A) $\sqrt{2gh}$ (B) $\frac{2Mghr^2}{I}$ (C) $\sqrt{\frac{2Mghr^2}{I}}$ (D) $\sqrt{\frac{2Mghr^2}{I+Mr^2}}$

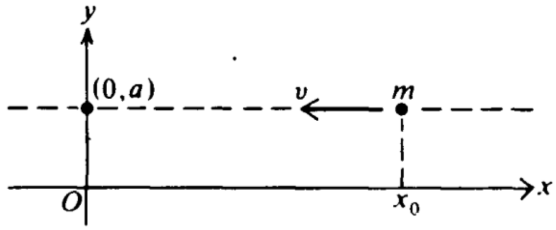
4. A car travels forward with constant velocity. It goes over a small stone, which gets stuck in the groove of a tire. The initial acceleration of the stone, as it leaves the surface of the road, is

   (A) vertically upward (B) horizontally forward (C) horizontally backward
   (D) upward and forward, at approximately 45° to the horizontal

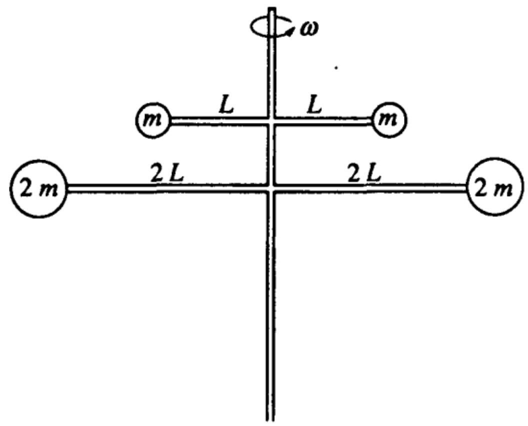
SECTION D – Angular Momentum

1. An ice skater is spinning about a vertical axis with arms fully extended. If the arms are pulled in closer to the body, in which of the following ways are the angular momentum and kinetic energy of the skater affected?

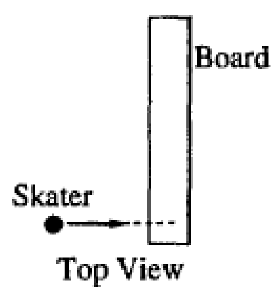
	Angular Momentum	Kinetic Energy
(A)	Increases	Increases
(B)	Increases	Remains Constant
(C)	Remains Constant	Increases
(D)	Remains Constant	Remains Constant



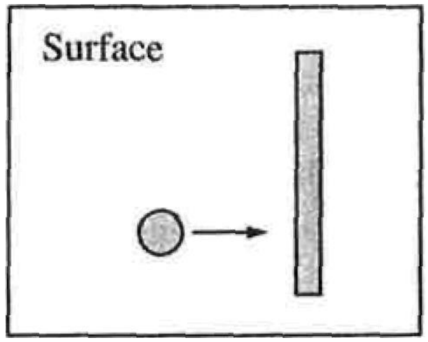
2. A particle of mass m moves with a constant speed v along the dashed line y = a. When the x-coordinate of the particle is x_o, the magnitude of the angular momentum of the particle with respect to the origin of the system is
   (A) zero (B) *mva* (C) mvx_o (D) $mv\sqrt{x_0^2 + a^2}$



3. The rigid body shown in the diagram above consists of a vertical support post and two horizontal crossbars with spheres attached. The masses of the spheres and the lengths of the crossbars are indicated in the diagram. The body rotates about a vertical axis along the support post with constant angular speed ω. If the masses of the support post and the crossbars are negligible, what is the ratio of the angular momentum of the two upper spheres to that of the two lower spheres?
   (A) 2/1 (B) 1/2 (C) 1/4 (D) 1/8



4. A long board is free to slide on a sheet of frictionless ice. As shown in the top view above, a skater skates to the board and hops onto one end, causing the board to slide and rotate. In this situation, which of the following occurs?
   (A) Linear momentum is converted to angular momentum.
   (B) Rotational kinetic energy is conserved.
   (C) Translational kinetic energy is conserved.
   (D) Linear momentum and angular momentum are both conserved.



Top View

5. **Multiple Correct.** A disk sliding on a horizontal surface that has negligible friction collides with a rod that is free to move and rotate on the surface, as shown in the top view above. Which of the following quantities must be the same for the disk-rod system before and after the collision? Select two answers.

I. Linear momentum
II. Angular momentum
III. Kinetic energy

(A) Linear Momentum
(B) Angular Momentum
(C) Kinetic Energy
(D) Mechanical Energy