Instructions: (1) Read the problem and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.

Question 01	**1.** If a bike wheel of radius 50 cm rotates at 300 rpm what is its angular velocity and what is the linear speed of a point on the outer edge of the wheel. (A) Angular velocity = 10 rad/s, linear speed = 5 m/s. (B) Angular velocity = 31.4 rad/s, linear speed = 15.7 m/s. (C) Angular velocity = 300 rad/s, linear speed = 150 m/s. (D) Angular velocity = 50 rad/s, linear speed = 25 m/s. (E) Angular velocity =31.4 rad/s, linear speed = 31.4 m/s.
Feedback on Each Answer Choice	A. Incorrect! It looks like you forgot to include π in your calculation of angular velocity.
	B. Correct! First convert rpm to rad/s to give angular velocity and then use $v=\omega r$ to find the linear speed of a point on the outer edge, where r is the radius.
	C. Incorrect! Remember rpm, is revolutions per minute and 1 revolution is 2π.
	D. Incorrect! Remember that 1 revolution is 2π.
	E. Incorrect! To find the linear speed you must multiply the angular velocity by the radius, $v=\omega r$.
Solution	**Known:** Wheel rotation: 300 rpm Wheel radius : r = 50 cm **Unknowns:** Angular velocity ω = ? rad/s Linear speed of a point on the outer rim of the wheel, v =? m/s **Define:** First convert rpm to radians per second, remember 1 rev =2π to give angular velocity. Convert radius to meters Linear speed $v = \omega r$, **Output:** Angular velocity $= 300 \frac{\text{rev}}{\text{min}} \times \frac{2\pi \text{ rad}}{\text{rev}} \times \frac{1 \text{ min}}{60 \text{ s}} = 10\pi \text{ rad/s} = 10 \times 3.14 \text{ rad/s} = 31.4 \text{ rad/s}$ r = 50 cm =0.5 m Linear speed $v = \omega r$ = 31.4 rad/s x 0.5 m = 15.7 m/s **Substantiate**: Units are correct, sig figs are correct, magnitude is reasonable. **The correct answer is (B).**

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Question No. 2 of 10

Instructions: (1) Read the problem and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.	
Question 02	**2.** A hard drive in a computer rotates at 3600 rpm, if it comes to a crashing halt in 9 s, what is the angular acceleration of the hard drive? (A) -800 rad/s^2 (B) -13 rad/s^2 (C) 377 rad/s^2 (D) -42 rad/s^2 (E) -3400 rad/s^2
Feedback on Each Answer Choice	A. Incorrect! Remember rpm is revolutions per minute and you need to convert to rad/s.
	B. Incorrect! Check that you included π when converting to rad/s.
	C. Incorrect! That is the initial angular velocity; we are looking for angular acceleration.
	D. Correct! Convert rpm to rad/s, to find the initial angular velocity, the final angular velocity is 0 rad/s and the time taken to change the angular velocity is 9s so we can calculate angular acceleration. The negative sign indicates that the disk is slowing down.
	E. Incorrect! Check that you are using the correct formula for angular acceleration.
Solution	**Known:** Initial angular velocity ω_I = 3600 rpm Final angular velocity, ω_f = 0 rad/s Time to stop = 9.0 s **Unknown:** Angular acceleration α = rad/s^2 **Define:** Convert rpm to rad/s Angular acceleration $\alpha = \frac{\Delta\omega}{t} = \frac{\omega_f - \omega_i}{t}$ **Output:** $\omega_I = 3600 \frac{\text{rev}}{\text{min}} \times \frac{2\pi \text{ rad}}{\text{rev}} \times \frac{1 \text{ min}}{60 \text{ s}} = 120\pi$ rad/s = 120 × 3.14 rad/s =377 rad/s $\alpha = \frac{0 - 377 \text{ rad/s}}{9 \text{ s}} = -42$ rad/s^2 **Substantiate**: Units are correct, sig figs are correct, magnitude is reasonable, negative sign indicates the disk is slowing down. **The correct answer is (D).**

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Question No. 3 of 10

Instructions: (1) Read the problem and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.	
Question 03	**3.** When started, the blades of an electric blender have an acceleration of 1700 rad/s/s. If the blades reach maximum speed in 0.50 seconds, what angular displacement do the blades cover? (A) 1700 rad (B) 425 rad (C) 850 rad (D) 210 rad (E) 420 rad
Feedback on Each Answer Choice	A. Incorrect! This is merely the angular acceleration. This is different from the angular displacement. Use the angular displacement formula.
	B. Incorrect! Don't forget that the time term is squared in the angular displacement formula.
	C. Incorrect! Don't forget there is a time squared term in the angular displacement formula.
	D. Correct! Use the angular displacement formula. Angular displacement equals initial angular speed times time plus angular acceleration times time squared divided by two.
	E. Incorrect! Don't forget that you need to divide by 2.
Solution	**Known:** Angular acceleration, α = 1700 rad/s^2 Time, t = 0.50 s Initial angular speed, ω_I = 0 rad/s **Unknown:** Angular displacement, θ = ? rad **Define:**. Find a formula that contains all of the given variables and the unknown. $\theta = \omega_i t + \frac{\alpha t^2}{2}$ In this case, the initial angular speed is zero, so that term drops out. $\theta = \frac{\alpha t^2}{2}$ **Output:** $\theta = \frac{1700 \text{ rad/s}^2 \times (0.5 \text{ s})^2}{2} = 210 \text{ rad}$ **Substantiate**: Units are correct, sig figs are correct, magnitude is reasonable. **The correct answer is (D).**

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Question No. 4 of 10

Instructions: (1) Read the problem and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.	
Question 04	**4.** A sphere, disk, and hoop all have equal masses and radii. They are started from rest at the top of a hill, and then they are released at the same time. Which one will get to the bottom last? (A) sphere (B) disk (C) hoop (D) hoop and disk tie for last (E) it will be a three way tie
Feedback on Each Answer Choice	A. Incorrect! Some of the mass of the sphere is located right at the axis of rotation. This means the sphere has the lowest moment of inertia of all the given items. Thus, it will actually finish first.
	B. Incorrect! Consider the moment of inertia of the disk. I = the sum of mr^2 Compare where its mass is distributed compared to the other items.
	C. Correct! Since the hoop has all of its mass located far away from the axis of rotation, it has the greatest moment of inertia. Thus, it will accelerate the least when a given torque is applied. So it will finish last in the race.
	D. Incorrect! The distribution of mass is different for the hoop and disk so they will not arrive at the same time.
	E. Incorrect! There are basic differences in how the mass of the objects is distributed. This affects their moment of inertia, which will determine the finishing order of the race.
Solution	The order of finish depends upon the moments of inertia of the objects. The one with the greatest moment of inertia will lose the race. The one with the least moment of inertia would win. Even if numerical values for the moments of inertia are unknown, we can still determine the relative order for the finish of the race. Consider the definition for moment of inertia: $I = \Sigma mr^2$ It describes the distribution of the mass about the axis of rotation. In all cases, some torque from gravity causes rotation. Consider the evenly distributed disk and compare it to the sphere. In the sphere, more of the mass is directly at the axis of rotation. The disk has a higher moment of inertia than the sphere. Thus, the disk would be slower. However, this effect is even more pronounced with the hoop. It has nearly all of its mass away from the axis of rotation. The hoop has the highest moment of inertia, so it would be the slowest. **The correct answer is (C).**

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Question No. 5 of 10

Instructions: (1) Read the problem and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.	
Question 05	**5.** Using the information from the picture, calculate the moment of inertia for the system shown: (A) 310 kg m^2 (B) 36 kg m^2 (C) 162 kg m^2 (D) 270 kg m^2 (E) 171 kg m^2
Feedback on Each Answer Choice	A. Correct! Find the moment of inertia for each component using $I = mr^2$ and then sum to give the total moment of inertia.
	B. Incorrect! The moment of inertia is dependent on r^2.
	C. Incorrect! The 6 kg mass is 5.0 m from the 3 kg mass; this is not the distance from the axis of rotation.
	D. Incorrect! The moment of inertia depends on r^2 not m^2.
	E. Incorrect! Check that you used the correct masses and radii.
Solution	**Known:** Mass m_1 = 3 kg Mass m_2 = 6 kg Radius r_1 = 2.0 m Radius r_2 = 2.0 m + 5.0 m = 7.0 m **Unknown:** Moment of inertia, I= ? kg m^2 **Define:** $I = \sum m_i r_i^2 = m_1 r_1^2 + m_2 r_2^2$ **Output:** $I = 3.0\text{ kg} \times (2.0\text{ m})^2 + 6.0\text{ kg} \times (7.0\text{ m})^2 = 12\text{ kg m}^2 + 294\text{ kg m}^2 = 306\text{ kg m}^2$ **Lowest number of sig figs is two so moment of inertia is 310 kg m^2** **Substantiate**: Units are correct, sig figs are correct, magnitude is reasonable. **The correct answer is (A).**

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Question No. 6 of 10

Instructions: (1) Read the problem and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.	
Question 06	**6.** A stubborn bolt cannot be removed even with the help of a wrench. Which would be more effective, doubling the length of the wrench handle or doubling the amount of force exerted on the wrench, or doing both together? (A) Doubling the length. (B) Doubling the force applied. (C) Doubling both factors. (D) Neither option changes the outcome. (E) You cannot determine without knowing the values for length and force.
Feedback on Each Answer Choice	A. Incorrect! Although this would increase the torque applied, another option would do more. Remember the definition of torque: T=Fl.
	B. Incorrect! Although this would increase the torque applied, another option would do more. Remember the definition of torque: T=Fl.
	C. Correct! This option would increase the torque the most. Since T=Fl, doubling the force, and doubling the lever arm changes the torque by a factor of four.
	D. Incorrect! Consider the torque formula. T=Fl. A change in either the force or lever arm will change the torque applied.
	E. Incorrect! You do not need to know the values for length and force. Consider the torque formula. T=Fl. A change in either the force or lever arm will change the torque applied.
Solution	Consider the torque formula: T=Fl. Doubling the force would double the torque by a factor of 2. Doubling the length of lever arm would change the torque by a factor of 2. Both items combined change the torque by a factor of 4. Thus changing both items is the most effective way to increase the torque applied. **The correct answer is (C).**

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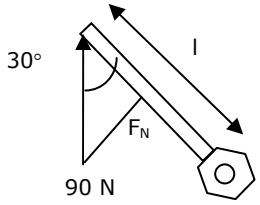
Question No. 7 of 10

Instructions: (1) Read the problem and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.	
Question 07	**7.** If you apply a 120 N force to the end of a wrench such that the angle between the force and wrench is 30° and the resulting torque is 30 N m, what is the length of the wrench? (A) 40 cm (B) 38 cm (C) 43 cm (D) 200 cm (E) 50 cm
Feedback on Each Answer Choice	A. Incorrect! The force used to find torque is the force perpendicular to the lever arm.
	B. Incorrect! Check that you are using the correct trig function to find the normal force.
	C. Incorrect! Check that you are using the correct trig function to find the normal force.
	D. Incorrect! To find the length divide torque by the force normal to the wrench.
	E. Correct! Find the force that is normal to the wrench and then to find the length divide the torque by the force normal to the wrench.
Solution	**Known:** Applied force F = 120 N Angle between wrench and applied force θ = 30° Torque τ = 30 N  **Unknown:** Length of wrench, l = ? m **Define:** $\tau = lF_N$ Where F_N is the force applied normal (perpendicular) to the wrench. Find F_N using trig: $\sin\theta = \frac{opp}{hyp} = \frac{F_N}{F}$ $F_N = F \sin\theta$ Use this in the equation for torque: Rearrange to find l $\tau = l F \sin\theta$ $l = \frac{\tau}{F \sin\theta}$ **Output:** $l = \frac{30\ N\ m}{120\ N \sin 30} = \frac{30\ N\ m}{60\ N} = 0.50\ m$ Convert meters to cm, 0.50 m x 100 = 50 cm **Substantiate**: Units are correct, sig figs are correct, magnitude is reasonable. **The correct answer is (E).**

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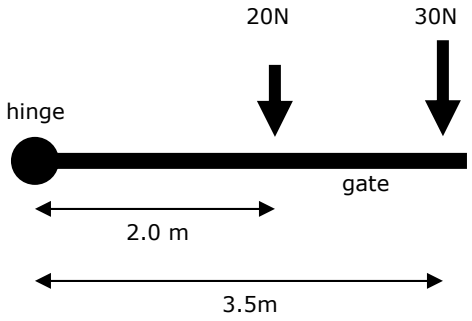
Question No. 8 of 10

Instructions: (1) Read the problem and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.	
Question 08	**8.** Two people push on a large gate as shown on the view from above in the diagram. If the moment of inertia of the gate is 90 kg m^2, what is the resulting angular acceleration of the gate? (A) 13050 rad/s/s (B) 6.5 rad/s/s (C) 1.16 rad/s/s (D) .72 rad/s/s (E) None of the above 
Feedback on Each Answer Choice	A. Incorrect! Newton's second law of rotational motion says that the net torque is equal to the moment of inertia times the angular acceleration.
	B. Incorrect! Be sure to use the correct distances and forces when finding the total torque. The person pushing with 30 N uses a lever arm of 3.5 m. The person pushing with 20 N uses a lever arm of only 2 m.
	C. Incorrect! Don't forget to include the torque for both people pushing. Their efforts add together to give the total torque on the gate.
	D. Incorrect! The net torque on the gate must be found. Torque equals force times lever arm. The torques are acting to rotate the object in the same direction, so they would be added together, not subtracted.
	E. Correct! First, the net torque on the gate must be found. Next, use this torque and the moment of inertia to find the angular acceleration. Use the rotational form of Newton's second law. The sum of the torques equals the moment of inertia time the angular acceleration.
Solution	**Known:** Force. F_1 = 20 N Force F_2 = 30 N Radius r_1 = 2.0 m Radius r_2 = 3.5 m Moment of inertia of the gate , I= 90 kg m^2 **Unknown:** Angular acceleration of the gate, α = rad/s/s **Define:** First, the net torque on the gate must be found. $T_{Total} = T_{person\ 1} + T_{person\ 2}$ $T_{Total} = F_1 l_1 + F_2 l_2$ Next, use this torque and the moment of inertia to find the angular acceleration. Use the rotational form of Newton's second law: $\Sigma T = I \alpha$ $F_1 l_1 + F_2 l_2 = I \alpha$ $\alpha = (F_1 l_1 + F_2 l_2)/I$ **Output:** T_{Total} =(30 N) 3.5 m+ (20 N) 2.0 m = 145 N m α = 145 N m/ 90 kg m^2 α=1.6 rad/s^2 **Substantiate**: Units are correct, sig figs are correct, magnitude is reasonable. **The correct answer is (E).**

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Question No. 9 of 10

Instructions: (1) Read the problem and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.	
Question 09	**9.** What is the angular momentum of 0.10 kg ball rotating on a thin wire of length 55 cm, and the angular speed is 15 rad/s. You can assume that wire has no mass. (A) 4538 kg m^2/s (B) 0.45 kg m^2/s (C) 0.83 kg m^2/s (D) 0.08 kg m^2/s (E) 0.03 kg m^2/s
Feedback on Each Answer Choice	A. Incorrect! Convert centimeters to meters.
	B. Correct! Find the moment of inertia using the mass of the ball and the radius of circle in meters. Then calculate angular momentum using $L = I\omega$.
	C. Incorrect! Inertia is proportional to the radius squared.
	D. Incorrect! To find moment of inertia use $I = mr^2$.
	E. Incorrect! Angular momentum $L = I\omega$.
Solution	**Known:** Mass of ball, m = 0.10 kg Radius of circle, r = 55 cm Angular speed of ball, ω = 15 rad/s **Unknown:** Angular momentum, L = ? kg m^2/s **Define:** Convert the radius from cm to m $L = I\omega$ Moment of inertia, $I = mr^2$ Substitute this into the equation for angular momentum. $L = mr^2\omega$ **Output:** Radius $r = 55\text{ cm} \times \frac{1\text{ m}}{100\text{ cm}} = 0.55\text{ m}$ $L = 0.1\text{ kg} \times (0.55\text{ m})^2 \times 15\text{ rad/s} = 0.45\text{ kg m}^2/\text{s}$ **Substantiate**: Units are correct, sig figs are correct, magnitude is reasonable. **The correct answer is (B).**

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Question No. 10 of 10

Instructions: (1) Read the problem and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.	
Question 10	**10.** A figure skater is executing a spin with their arms and legs near their body and axis of rotation. Then they move their arms and legs outward away from the axis of rotation. Which of the following accurately describes the changes that take place? (A) Their angular momentum and angular speed increase, their moment of inertia stays constant. (B) Their angular momentum and angular speed increase, their moment of inertia decreases. (C) Their angular momentum stays constant, their angular speed decreases, their moment of inertia increases. (D) Their angular momentum stays constant, their angular speed increases, their moment of inertia decreases. (E) None of the above
Feedback on Each Answer Choice	A. Incorrect! The moment of inertia will definitely change. Consider how moving the appendages outward changes the moment of inertia.
	B. Incorrect! Consider the meaning of conservation of angular momentum. Some changes may occur, but angular moment will be conserved.
	C. Correct! By moving their appendages outward they move their mass farther from the axis of rotation. This makes it more difficult to rotate, thus their moment of inertia is greater. This changes the angular speed. Since it is more difficult to rotate, their angular speed slows. Since angular momentum is conserved, it doesn't change at all.
	D. Incorrect! This situation would be correct if the skater moved their arms and legs inwards. The situation here is opposite.
	E. Incorrect! Consider angular momentum. Predict the change in the moment of inertia, and then see how that affects the other two variables.
Solution	The change that the skater makes affects the moment of inertia. By moving their appendages outward they move their mass farther from the axis of rotation. $I = \Sigma mr^2$ This makes it more difficult to rotate, thus their moment of inertia is greater. This changes the angular speed. Since it is more difficult to rotate, their angular speed slows. Since angular momentum is conserved, it doesn't change at all. The two previous changes cancel out and give no not affect on the angular momentum. $L = I\omega$ moment of inertia increases, angular speed decreases, but the angular momentum stays the same. **The correct answer is (C).**

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