APPC, Mechanics: Unit γ HW 2

Name: ______________________________
Hr: ___ Due at beg of hr on: __________

Uγ, HW2, P1
Reference Videos: (1) "Rotational Kinematics"
(2) "Rotational Kinematics (Part II)"
YouTube, lasseviren1, ROTATIONAL MOTION playlist

A. A **radian** is the angle subtended when, for example, a point on a circle has rotated (to a new location) through an arc length that is equal to the circle's ______________.

B. Complete the table at right.

Variable	Name of the quantity	Unit
$\vec{\theta}$		
$\Delta\vec{\theta}$		
$\vec{\omega}$		
$\vec{\alpha}$		

C. Complete the table at right.

Variable	Specific name of the quantity	Equation
$\vec{\omega}_{avg}$		
$\vec{\omega}_{inst}$		
$\vec{\alpha}_{avg}$		
$\vec{\alpha}_{inst}$		

D. Below the four Kinematics Equations shown, write each equation's rotational analog.

$v_f = v_o + at$ $\Delta x = \frac{1}{2}(v_f + v_o)t$ $\Delta x = v_o t + \frac{1}{2}at^2$ $v_f^2 = v_o^2 + 2a\Delta x$

E. What condition MUST be satisfied, in order to use the equations you wrote in your Part D answers?

F. An object is rotating at an initial angular velocity of +2 rad/s and has a constant angular acceleration of +3 rad/s^2. Showing your work, determine, after 4 seconds have elapsed, the:

i. final angular velocity

ii. angular displacement

G. How many revolutions has the object of Part F made, in the 4 seconds mentioned?

Uγ, HW2, P2
Reference Video: "Rotational Kinematics (Part II)"
YouTube, lasseviren1, ROTATIONAL MOTION playlist

A. Write the "Bridge Equations" that connect linear (or *translational*, or *tangential*) and rotational motion.

i. displacement: ii. velocity: iii. acceleration:

B. An object rotates in accord with the position-time function $\theta(t) = 2t^3 - t^2 - 7t + 3$. Determine the:

i. angular velocity at t = 2 s

ii. angular acceleration at t = 1 s

C. Can the angular forms of the four Kinematics Equations
(see HW2, P1, Part D) be applied to the object in Part B? (circle) YES NO

D. Briefly explain your Part C answer.

E. We have dealt with centripetal acceleration a_c a lot, particularly in our study of Newton's 2nd law.
To review, write the simple equation we have always used for a_c , up to this point, i.e., a_c = ?

F. Substitute the right side of your Part Aii answer into your Part E answer, then simplify.
This gives you another equation you can use to find centripetal acceleration a_c.

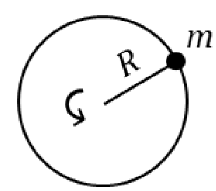
G. Circle your answers below. In each case, assume that the object IS rotating.

i. If $\alpha = 0$, then ω is: constant and zero constant and nonzero continuously changing

ii. If $\alpha \neq 0$, then ω is: constant and zero constant and nonzero continuously changing

H. A rotating disk of radius R has a smaller mass m attached to its edge. For each description below, decide which Choice (I, II, III, IV, V, or VI) most precisely applies and write that choice in the blank. There is only ONE correct answer for each part, *based on the italicized and underlined* information. HINT: Of the six Choices, one is NOT used, and one is used TWICE.

I. a_c is constant and zero
II. a_c is constant and nonzero
III. a_c is continuously changing
IV. a_t is constant and zero
V. a_t is constant and nonzero
VI. a_t is continuously changing



i. If $\alpha = 0$, then – *as a result of m going in a circular path* – m will experience Choice ____.

ii. If $\alpha = 0$, then – *as a result of m NOT changing its linear speed* – m will experience Choice ____.

iii. If $\alpha \neq 0$ but constant, then – *as a result of m going in a circular path* – m will experience Choice ____.

iv. If $\alpha \neq 0$ but constant, then – *as a result of m changing its linear speed* – m will experience Choice ____.

v. If $\alpha \neq 0$ and changing, then – *as a result of m going in a circular path* – m will experience Choice ____.

vi. If $\alpha \neq 0$ and changing, then – *as a result of m changing its linear speed* – m will experience Choice ____.

Uγ, HW2, P3
Reference Videos: (1) "Torque"
(2) "Torque and the Cross Product (Part II)"
YouTube, lasseviren1, ROTATIONAL MOTION playlist

A. Newton's 1st Law of Rotation: An object will remain ____________________ or will continue with ____________ ____________ __________ unless acted upon by a ____ ____________ ________.

B. Write the definition for **torque**.

C. Write ONE equation for finding the *magnitude* of torque.

D. Write TWO equations that show the *vector* nature of torque.

E. $\vec{r}$ is a vector that starts at the _______ of rotation and extends to the point where the _________ is applied. One common term for $\vec{r}$ is the _________ _____. When using the **cross product** on $\vec{r}$ and $\vec{F}$, these two vectors must be (mentally, anyway) oriented _______-___-_______. This is different from when you are simply adding vectors (like you did in first-year Physics), where you learned that vectors to be added must be oriented _______-___-_______. What the narrator writes as $r_{\perp}$ is termed the _______________ _________ _____. The imaginary line that extends infinitely in the exact direction that the force points is often called the _______ ___ _________ of the force. If this imaginary line goes through the _______, there is zero ____________.

F. We learned a while ago that the *dot product* is also called the *scalar product*. To review: Why is that?

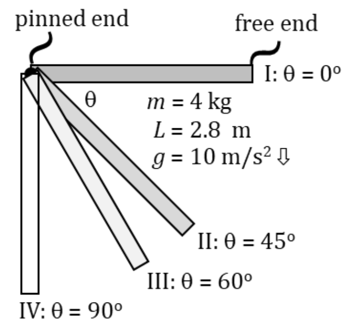
G. As a follow-up to your Part F answer... Why is the *cross product* also called the *vector product*?

H. CIRCLE whether each operation is commutative or not. If an operation IS commutative, then also write one example, using numbers or variables, whichever you prefer. Otherwise, no example is needed.

i. addition	COMMUTATIVE	NOT COMMUTATIVE	Example, if commutative:
ii. subtraction	COMMUTATIVE	NOT COMMUTATIVE	Example, if commutative:
iii. division	COMMUTATIVE	NOT COMMUTATIVE	Example, if commutative:
iv. multiplication	COMMUTATIVE	NOT COMMUTATIVE	Example, if commutative:
v. dot product	COMMUTATIVE	NOT COMMUTATIVE	Example, if commutative:
vi. cross product	COMMUTATIVE	NOT COMMUTATIVE	Example, if commutative:

Uγ, HW2, P4

Reference Videos: (1) "Torque and the Cross Product (Part II)"
(2) "Torque and the Cross Product (Part III)"
YouTube, lasseviren1, ROTATIONAL MOTION playlist



A. Torque is the rotational analog of ____________.

B. The figure shows a rod of mass 4 kg and length 2.8 m that is pinned to the wall at its left end; its right end is free to move. The rod is released from rest in Position I and the right end begins to fall; it reaches Positions II, III, and IV in succession. (If you know *sin* and *cos* values for simple right triangles, you will NOT need a calculator for this exercise.)

i. In EACH of the four depictions in the figure, draw a dot showing where the rod's center of mass is. In the Position I depiction ONLY, label this dot "com". (Ha! "dot-com"... Get it? ☺)

ii. The net torque on the rod is generated by the force of the rod's weight. This weight is a constant for all four depictions. What are the magnitude and direction of this force?

iii. Torque also depends on the effective lever arm, which the narrator denotes as $r_\perp$. What is the effective lever arm for each rod configuration? (There is no need to show work.)

$r_\perp$ for I = $r_\perp$ for II = $r_\perp$ for III = $r_\perp$ for IV =

iv. Use your Parts Bii and Biii answers to calculate the torque for each depiction. Show your work.

τ for I = τ for III =

τ for II = τ for IV =

v. Look back at your Part A answer. To review... According to Newton's 2nd law, the larger THAT quantity is (for a given mass), the larger will be the mass's ______________________.

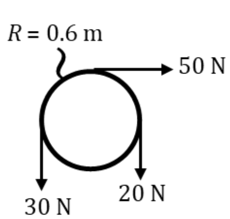
vi. Now, follow the logic here... Torque, we said, is the rotational analog of your Part A answer. Therefore – according to the *rotational* version of Newton's 2nd law (more on this later) – the larger the torque is (for a given object), the larger will be the object's *rotational analog to your Part Bv answer*, i.e., the larger will be the object's ________________ ______________________. And we see, from your Part Biv answers, that your previous answer will be maximized at Position ____.

vii. At which Position will the rod's angular speed be maximized? (CIRCLE) I II III IV

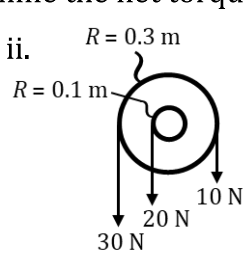
viii. Explain why your last answer in Part Bvi and your Part Bviii answer are NOT the same.

C. As shown in the second video, determine the net torque (direction – i.e., CW or CCW – and magnitude).

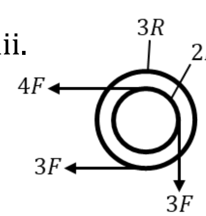
i.



ii.



iii.



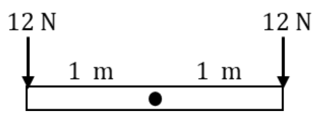
Uγ, HW2, P5

Reference Video: "Static Equilibrium Problems in Mechanics"
YouTube, lasseviren1, ROTATIONAL MOTION playlist

A. The conditions for static equilibrium (in mechanics) are: no ____________________ (i.e., ___ = ZERO) AND no ______________ ____________________ (i.e., ___ = ZERO). From Newton's 2nd laws of (1) translation and (2) rotation, this means that, in the first case, ______ = ZERO; in the second case, ______ = ZERO.

B. The objects below are subject to ONLY the forces shown. For each case, determine the net force on the object AND the net torque about the object's center of mass, which is labeled with a • . Finally, circle whether the object is in a state of static equilibrium or not.

i.

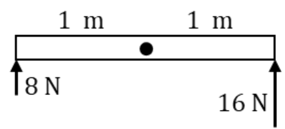


F_{net} =

τ_{net} =

In static equilibrium? YES NO

iii.

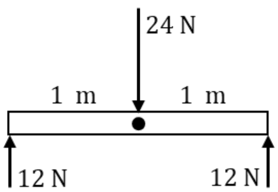


F_{net} =

τ_{net} =

In static equilibrium? YES NO

ii.

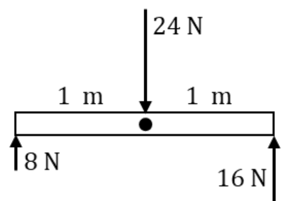


F_{net} =

τ_{net} =

In static equilibrium? YES NO

iv.

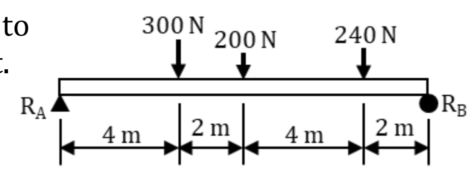


F_{net} =

τ_{net} =

In static equilibrium? YES NO

Refer to the figure at right to answer the following questions. Your goal is to determine the two support reactions, R_A and R_B. Ignore the beam's weight.



C. Into the figure, draw two upward-pointing vectors, one at each end. These vectors represent the reactions (i.e., the forces) R_A and R_B.

D. For static equilibrium, F_{net} must equal zero. Here, that means that "the sum-of-the-ups" must equal "the sum-of-the-downs". Write an equation expressing this. (HINT: Your equation will have THREE "+" signs in it.)

E. You can simplify one side of your Part D answer. Do that, and rewrite the equation.

You cannot solve your Part E equation because it has two unknowns. So we need another equation, this one satisfying the other condition of equilibrium, i.e., that τ_{net} must also equal zero. To do this, we choose some point (ANY point) of rotation and write the equation: "CW-torques = CCW-torques".

F. Let's choose the left end of the beam as the rotation point, about which you will take the torques. Now, YOU write the torque equation, as described above. (HINT: Your equation will have ONE unknown and TWO "+" signs in it.)

G. Solve your Part F answer for the unknown.

H. Substitute your Part G answer into your Part E answer to find the other unknown. You did it! ☺

I. Why is it convenient to choose your rotation point along the line of action of one of your unknowns?