Rotational Motion Equations U6a

Everything we learned about translational motion applies to ______________ motion. It is just that instead of measuring distance in __________ we measure _________ in ___________. We can convert between the two systems using d = ______. This also means v = ____ and a = _____. Substituting these conversions into our 5 equations of ______________ motion gives us 5 equations rotational motion.

Torque

Torque is the angular version of force. It has the formula $\tau = rF_T$. In other words, this means that the angular force (torque) is equal to the tangential ___________ times the distance between where the _________ is applied and the pivot point (a.k.a. lever arm; separation of fulcrum and effort).

It is important to note that it is only the ______________ component of a force that causes objects to rotate. The _____________ component does not add or subtract to the net torque no matter how large it gets.

It is also important to note that, since torques involve rotation, a positive torque means the object _____________ counterclockwise, while a negative torque tries to make __________________ rotation happen. (Side note: Just like you can define up to be negative, you can reverse the meaning of the torque signs too, just be consistent.)

Instead of talking about the tangential component of the force, the book instead says the lever arm is the perpendicular ___________ from the axis of ____________ to a line drawn along the direction of the ____________. This reduced-length lever arm is then multiplied by the full force.

All I have to say about this is

1. I don't like this definition. A lever is a physical object used for twisting: like a wrench or crow bar. The arm is the part you physically grab. So, imaginary geometrical construction lines are not involved.
2. Mathematically, shrinking the physical lever arm this way and multiplying by the full force is exactly the same thing as using the full-length lever arm and multiplying by the tangential portion of the force. So, why complicate life with the imaginary lines.

That said, the books way of defining torque is a clever shortcut for certain problems.

Gravity and Torque

Gravity is a force that can cause unbalanced objects to rotate. When gravity creates a torque, it behaves as though the entire force of gravity (aka ___________) of the object pulls straight down at exactly the balance point of the object.

For your lab, the meterstick creates a counterclockwise torque. The mass creates a clockwise torque. When those two torques are ___________ then the combination of the meterstick and the free-mass does not rotate and the system is ____________________. So, set the two torques equal to solve. Remember, r for the meterstick is the distance from the "naked" balance point to the new balance point (with the mass attached).

Rotational Equilibrium U6b

- Similar to linear equilibrium, rotational equilibrium is when an object ______________ or __________________________. This occurs when ______ = 0.
- Note: an object is in total static equilibrium if _________ and ________ are true. Some examples: a brick _________________, an elevator _____________________, a windmill ________________________, a marble __________________________.
- Newton's 1st Law will thus become: An object at rest, in motion, or ____________ will continue its _________ or rotation unless acted upon by a ________ or __________. Be certain to remember that a moving, rotating object _________ in static equilibrium.

Applying Newton's 1st Law to Static Equilibrium

- Linear equilibrium problems are always about choosing _________ and setting a sum of _________ equal to 0N. Rotational equilibrium problems require choosing a _____ to measure r from and setting all _________ = ______. Note: torque is a vector with directions of ____________________(CCW) and _______________(CW). The _____ (a.k.a. axis of___________ or __________) or a stationary object is chosen to be wherever the math will be __________ (i.e. zero out non-essential torques).

Examples:

Rectangle in space (prove pivot point doesn't matter)

Teeter Toter

Scaffold

Boom

Ladder

Newton Gets Torqued U6c

- Newton's 2nd Law states ____________. Torque = __________. So, Newton's _________ Law becomes _____=_____ => ____=______
- If there are multiple masses this becomes ____=______=_____, where I = ______ and is called the _____________________ (literally how _______ it is to _____/_____ the _____________ of an object).
- Note: Moment of Inertia depends on the _______ of ______________.

Assorted Moments of Interia (p. 230)

A number of small mass lumps

Rod Rotated about Middle

Hoop or Cylindrical Shell

Rod Rotated about End

Disk or Solid Cylinder

Empty Soup Can (no lid)

Solid Sphere

Wagon Wheel

Conservation Of Energy (Again) U6d

- To make a block slide across a smooth floor, you must ________and do ________ on it. This is what gives the block __________________.
- To make a propeller spin, you must ____. This is what gives the propeller __________________________________.
- $KE_t = ½ mv^2$ Since v = _____, KE_r = __________ = __________ (for a single lump)
  = ___________ = _________ (for a distribution of mass)
- If you are sliding up a hill, you can use ________________________ for find out how far you slide. ___________________ = _______________________
- If you are rolling up a hill, this becomes
  __________________________ = _________________________
  (Note: You are rarely given both v and ω, so expect to use ___________.)

Conservation Of Momentum (Again)

- To cause an object's momentum to change _____________________________________.
- To cause an object's angular momentum to change ______________________________. To make a propeller spin, you must ____.
- In the absence of a net force, conservation of momentum says __=__=>_____=_____ (which is very boring for a single system).
- In the absence of a net torque, ___ = ___ => _____ = _____ (which is much more interesting for a single system, because even though systems rarely loose ______, the pieces of can easily change ______________).

Sliding Masses on Rod

Dropping Gum on a Hoop