PH202 Midterm Review Session Solutions

Tuesday, January 22, 2019 6:17 PM

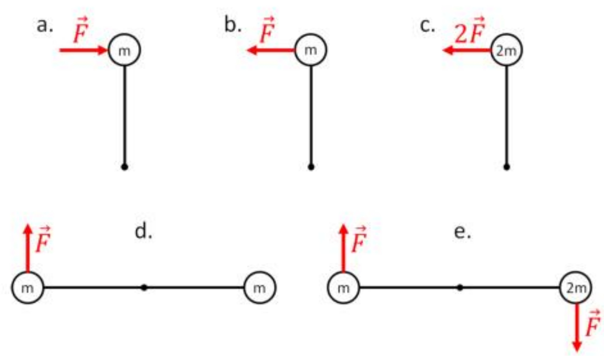
Physics 202

Midterm 1 Review Session

1/22/2019

These are example problems of similar *format* to those that will appear on the exam (unless otherwise indicated). They may be more or less difficult than is appropriate for an exam.

1. Rank the following angular accelerations from most negative to most positive, indicating if any are equal. Assume point masses at the end of massless rods. (example: $\alpha_a > \alpha_b = \alpha_c > \alpha_d$)



Ranking: $\alpha_a < \alpha_e < \alpha_d < \alpha_b = \alpha_c$

$\tau = I\alpha$, $\alpha = \frac{\tau}{I}$

$\alpha_a = -\frac{Fr}{mr^2} = -\frac{F}{mr}$

$\alpha_b = +\frac{F}{mr}$ $\alpha_c = +\frac{F}{mr}$

$\alpha_d = -\frac{F}{2mr}$ $\alpha_e = \frac{-2F}{3mr}$

$I_a = mr^2$ $I_e = 3mr^2$ $\tau_d = -Fr$

$I_b = mr^2$ $\tau_a = -Fr$ $\tau_e = -2Fr$

$I_c = (2m)r^2$ $\tau_b = +Fr$

$I_D = 2(mr^2)$ $\tau_c = +2Fr$

For questions 2 through 5 **fill in the square** next to all correct answers, a given problem may have more or less than one correct answer. Each correctly chosen answer will receive two points. There are 9 correct answers in this section and only the first 9 filled in answers will be graded. There is no partial credit.

2. Which of the following situations describes an object in rotational dynamic equilibrium?

☐ a. A soccer ball rolling through the grass
■ b. A record spinning on a record player at a constant velocity
■ c. Your food spinning while it is heated in a microwave (unless your m/w is funny!)
☐ d. A merry-go-round at rest with no angular velocity
■ e. A Frisbee™ flying through the air (ignoring air resistance).

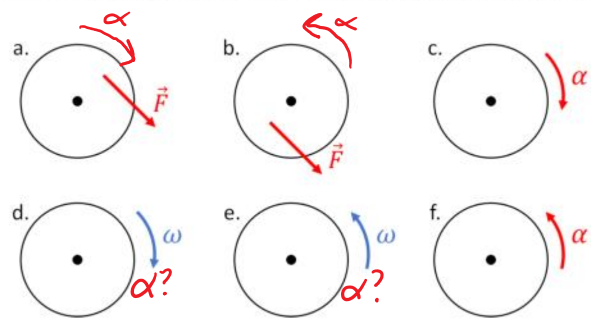
3. An ant is placed on a spinning record. The ____________ of the ant changes depending on the radius it is placed, while the ____________ does not change.

☐ a. angular velocity, tangential velocity
■ b. tangential velocity, angular velocity
☐ c. angular momentum, rotational kinetic energy
☐ d. radial acceleration, tangential acceleration
☐ e. tangential acceleration, radial acceleration
■ f. radial acceleration, radial velocity

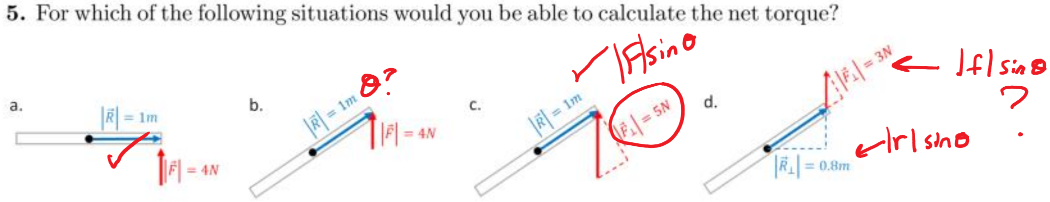
$\sim mr^2$
$L = I\omega$
$KE_{rot} = \frac{1}{2} I \omega^2$
$a_{radial} = \frac{v^2}{r} = \omega^2 r$
$a_{tangent} = \alpha r$

4. Which of the following situations will necessarily have a positive angular acceleration?

☐ a.
■ b.
☐ c.
☐ d.
☐ e.
■ f.



5. For which of the following situations would you be able to calculate the net torque?



■ a.
☐ b.
■ c.
☐ d.

$\tau = |r|\,|f| \sin\theta$

6. A disk begins at rest and experiences a torque of +99 Nm. The initial angular acceleration of the disk is 0.01 $\frac{rad}{s^2}$.

a. What is the moment of inertia of the disk?

$\tau = I\alpha \quad I = \frac{\tau}{\alpha} = \frac{99}{0.01} = 9900 \text{ kgm}^2$

b. If the disk has a diameter of 10.0 cm, what is the mass of the disk? (The moment of inertia of a solid disk is $\frac{1}{2}mr^2$) $r = 5\text{cm} = 0.05\text{m}$

$I = \frac{1}{2}mr^2$

$9900 = \frac{1}{2}m(0.05)^2 \quad m = \frac{2(9900)}{(0.05)^2} = 7,920,000 \text{ kg}$

c. After 10.0 seconds, what is the tangential velocity of a point on the disk rim?

$v_t = \omega r$

$\omega_f = \omega_i^{\,0} + \alpha \Delta t$

$= (0.01)(10) = 0.1 \frac{rad}{s} \Rightarrow v_t = (0.1)(0.05)$

$= 0.005 \frac{m}{s} = 5 \frac{mm}{s}$

d. After 10.0 seconds, what is the tangential acceleration of a point on the disk rim?

$a_t = \alpha r = (0.01)(0.05) = 0.0005 \frac{m}{s}$

$= 0.5 \frac{mm}{s}$

$= 500 \frac{\mu m}{s}$

e. After 10.0 seconds, what is the radial acceleration of a point on the disk rim?

$a_r = \omega^2 r = (0.1)^2(0.05) = (0.001)(0.05) = 0.00005$

$= 50 \frac{\mu m}{s}$

7. Bernice is in outerspace cleaning up Benny's sloppy log placement. Her rocket scooter can exert a force of 400 N on a log. A 10 meter log needs rotating.

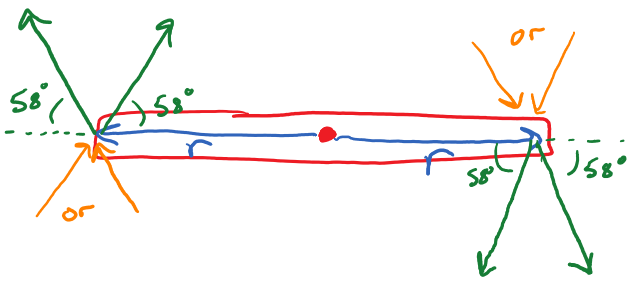
a. If she needs to apply a torque of -1700 Nm to the log, find an angle at which Bernice could apply the scooter to the log. ← end of the log

$$\tau = -1700 = (400)(5)\sin\theta$$

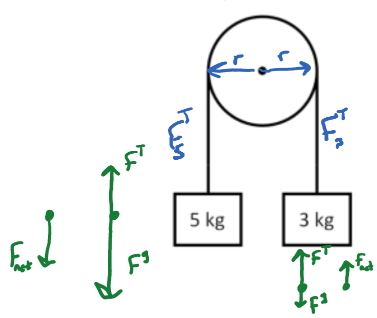
$$\sin\theta = -\frac{1700}{2000} = 58.2^\circ$$

or 122°

b. Draw a picture with the four possible force vectors Bernice could apply to the log if it were oriented horizontally.



8. Two masses of 5 kg and 3 kg are attached via a long massless string. The string is placed over a disk of mass 10 kg and radius 80 cm such that the masses hang on either side of the disk as shown. What is the linear velocity of the 3 kg mass 4 seconds after the system is allowed to move?



disk: $\tau_{net} = F_5^T r - F_3^T r = I\alpha = \frac{1}{2}m_d r^2 \frac{a}{r} = \frac{1}{2}m_d r a$ ①

3 kg: $F_{net} = -m_3 g + F_3^T = m_3 a$ ②

5 kg: $F_{net} = m_5 g - F_5^T = m_5 a$ ③

3 eqs, 3 unknowns (a, F_5^T, F_3^T)

② ⇒ $F_3^T = m_3 a + m_3 g$

③ ⇒ $F_5^T = m_5 g - m_5 a$

② + ③ → ① ⇒ $m_5 g - m_5 a - m_3 a - m_3 g = \frac{1}{2}m_d a$

$$m_5 g - m_3 g = \left(\frac{1}{2}m_d + m_3 + m_5\right) a$$

$$a = g\left(\frac{m_5 - m_3}{\frac{1}{2}m_d + m_3 + m_5}\right) = 1.51\ m/s^2$$

$v_f = v_i^{\,0} + a\Delta t$

$v_f = (1.51\ \frac{m}{s^2})(4s)$

$v_f = 6.03\ m/s$