Exam 3
Phys 220- Fall 2014

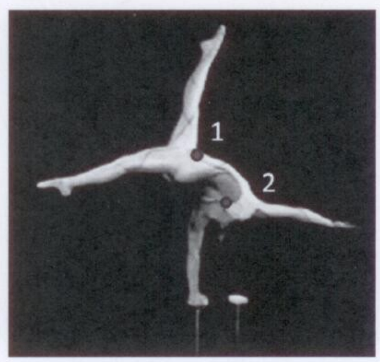
Name: Solution Group: ______

1. The angular equivalent of velocity is
   a. θ
   b. ω
   c. α
   d. x
   e. v

2. The rotational equivalent of force is
   a. angular velocity
   b. angular acceleration
   c. angular momentum
   d. moment of inertia
   e. torque

3. The angular equivalent of mass is
   a. momentum
   b. angular velocity
   c. angular momentum
   d. impulse
   e. moment of inertia

4. A gymnast holds a pose as shown in the diagram to the right. Identify the location of their center of mass.
   a. Position 1 over the point of support
   b. Postion 2
   c. To the left of position 1
   d. Between positions 1 and 2
   e. To the right of position 2



A pitcher throws a 0.145 kg baseball. The ball is traveling at 45 m/s just before it is hit by a 0.85kg bat. The point of the bat that comes in contact with the ball was traveling at 18 m/s just before it hits the ball. The ball has a speed of 51 m/s after the hit.

5. What is the momentum of the bat-ball system before the hit?
   a. 6.5 kg m/s
   b. 7.4 kg m/s
   c. 8.8 kg m/s
   d. 15 kg m/s
   e. 22 kg m/s

$m_1 = 0.145\ kg$

$m_2 = 0.85\ kg$

$V_{1i} = 45\ m/s$

$V_{2i} = -18\ m/s$

$$m_1 V_{1i} + m_2 V_{2i} = P_i = 0.145 kg\ 45 m/s + 0.85 kg (-18 m/s)$$
$$= 6.525\ kg\ m/s + -15.3\ kg\ m/s$$
$$= -8.775\ kg\ m/s$$

6. What is the momentum of the bat-ball system right after the hit?
   a. 6.5 kg m/s
   b. 7.4 kg m/s
   c. 8.8 kg m/s
   d. 22 kg m/s
   e. 23 kg m/s

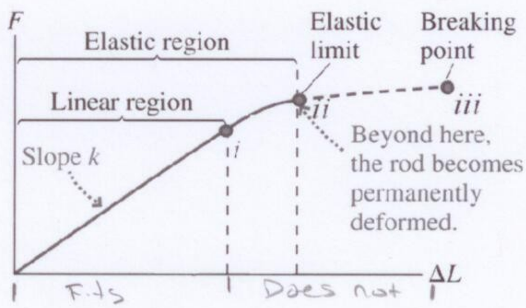
$\vec{P}_i = \vec{P}_f$

7. A grocery store scale in the fruit and vegetable department reads 2.5 kg when several apples are set into the tray. If this causes the tray to lower 3.0 cm, what is the spring constant of the scale.
   a. 82 N/m
   b. -82 N/m
   c. -820 N/m
   d. 820 N/m

$F = -kx$

$\frac{-mg}{-x} = k = \frac{2.5\,kg\ 9.8\,m/s^2}{0.03\,m} = 817\ N/m$

8. Hooke's law, $F = -kx$, applies to springs or elastic materials with a linear response to stress such as the plastic spoons. Which portion of the graph on the right does Hooke's law ***not*** fit?
   a. Origin to point *i*
   b. Origin to point *ii*
   c. Between point *i and ii*
   d. Between *i* and *iii*.
   e. Between points *ii* and *iii*



9. Why does a squishy cell phone case protect your phone when you drop it?
   a. It spreads the force out over time
   b. it reduces the force more time
   c. it reduces the impulse
   d. it reduces the time of impact
   e. It spreads the force out over a larger area

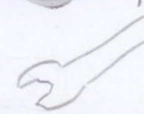
$\vec{J} = \vec{F}\,\Delta t = m\Delta\vec{v}$

$\downarrow\ \uparrow$

10. A mechanic is loosening a bolt and has poor access. She can reach in and only pull straight up on the wrench handle. As the wrench shown turns counterclockwise, is she able to apply more or less torque with the same force?
   a. As the wrench turns, the torque decreases.
   b. As the wrench turns, the torque stays the same.
   c. As the wrench turns, the torque increases.

$\uparrow \vec{F}$

$\uparrow \vec{F}$



Less Force perpendicula to the lever arm

11. Consider a clay ball and a rubber bouncy ball. They have identical size and mass. Both are thrown at you with the same velocity, which will hurt more?
   a. equal because the impulse delivered will be the same.
   b. Rubber bouncy ball will hurt more.
   c. Clay ball will hurt more.
   d. Not enough information

Greater change in momentum so a greater force

12. A Catcher catches a 0.145 kg baseball that is traveling at 45 m/s. If the Catcher brings the ball to rest in 0.10 s, determine the force on his glove.
    a. 15 N
    b. 33 N
    c. 45 N
    d. 65 N

$\vec{J} = \vec{F}\,\Delta t = m\Delta\vec{v}$

$F = \dfrac{m\Delta v}{\Delta t} = \dfrac{0.145\,kg\,(0\,m/s - 45\,m/s)}{.10\,s} = -65\,N$

13. When our legs bear our weight, the bones compress slightly. Based on our model of stretching and compressing, where does the compression of the bone fit? The model is stress equals Young's modulus times the strain:

$$\frac{F}{A} = Y\frac{\Delta L}{L}$$

Compression

    a. stress
    b. strain
    c. Young's modulus
    d. does not fit

Stress = Y Strain

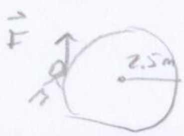
↑

Young's modulus

A boy is sitting on the edge of a merry-go-round 2.5 m from the center, while his sister pushes it. The sister applies a Force of 250N for 2.0 seconds. If the merry-go-round started at rest, has no friction, and accelerates with a constant angular acceleration of 0.9 rad/s^2,

14. What is torque applied by this push?
    a. 250 Nm
    b. 500 Nm
    c. 625 Nm
    d. Not enough information

$\tau = F \cdot d = 250\,N \cdot 2.5\,m = 625\,Nm$



15. After 30 seconds from the start of the push, what is the boy's angular displacement?
    a. 1.8 rad
    b. 50 rad
    c. 52 rad
    d. 54 rad

$\theta_i = 0$ rad
$\theta_f = ?$
$\omega_i = 0$ rad/s
$\omega_f = ?$
$\alpha = 0.9$ rad/s^2
$\Delta t = 2.0$ s

$\theta_f = 0 + 0 + \frac{1}{2}\,0.9\,\text{rad/s}^2\,(2.0\,s)^2 = 1.8$ rad

$\omega_f = 0 + 0.9\,\text{rad/s}^2\,(2.0\,s) = 1.8$ rad/s

$\theta_i = 1.8$ rad
$\theta_f = ?$
$\omega_i = 1.8$ rad/s
$\omega_f = 1.8$ rad/s
$\alpha = 0$ rad/s^2
$\Delta t = 28$ s

$\theta = 1.8\,rad + 1.8\,\text{m/s} \cdot 28\,s$
$= 1.8 + 50.4$
$\boxed{= 52.2\,rad}$

16. The ***angular acceleration*** of the boy is
    a. Constant during the push
    b. Increasing during the push
    c. Decreasing during the push
    d. Not enough information

$\alpha = \dfrac{\Delta\omega}{\Delta t}$

17. Determine the ***centripetal acceleration*** of the boy *after* the push.
    a. 0 m/s^2
    b. 0.9 m/s^2
    c. 1.3 m/s^2
    d. 2.3 m/s^2
    e. 8.1 m/s^2

$a_c = v^2/r = \omega^2 r = \left(1.8\,\text{rad/s}\right)^2 2.5\,m$

$= 8.1\,\text{m/s}^2$

18. If you're jumping your dirt bike and you want to rotate your bike forward, you should
   a. Rev the engine to make the back tire spin faster forward.
   b. Put on the brake
   c. Nothing will help you in the air

The brake stops the wheels from turning forward something else has to rotate forward to conserve angular momentum.

Show all your work for credit on the following problems.

16

19. Two rams are running at each other and butt heads. The first ram has a mass of 50 kg and is traveling at 6 m/s and the other ram has a mass of 60 kg and is traveling at 7 m/s. The 50 kg ram bounces backwards at 2 m/s after the collision.
   a. Determine the final speed of the 60 kg Ram immediately after the collision.
   b. What is the impulse delivered to each Ram?

A skinny, 5.0 kg, 2.0 meter long, tree branch is growing straight out, horizontal to the ground. A fat raccoon, 25 kg, cruises out onto the branch for a nice big juicy peach (1 kg). The skinny little branch can handle a total of 415 Nm of torque.

11

20. Determine the center of mass of the raccoon, peach, branch system when the raccoon is only 0.50 m out from the tree trunk. Clearly define where you are measuring *from* (eg. Left end, right end, center…).

11

21. Can the raccoon get the peach? How far can the raccoon go before the branch breaks and dumps him on the ground?

19. before

50kg $\xrightarrow{}$ V_{1i} 60kg $\xleftarrow{}$ V_{2i}

after

$\leftarrow V_{1F}$? V_{2F}

$m_1 = 50\,kg$
$V_{1i} = 6\,m/s$
$V_{1f} = -2\,m/s$
$m_2 = 60\,kg$
$V_{2i} = -7\,m/s$
$V_{2f} = ?$

$$m_1V_{1i} + m_2V_{2i} = m_1V_{1F} + m_2V_{2F}$$
$$50kg\,6m/s + 60kg(-7m/s) = 50kg(-2m/s) + 60kg\,V_{2F}$$
$$300kg\,m/s - 420kg\,m/s = -100kg\,m/s + 60kg\,V_{2F}$$
$$-120kg\,m/s = -100kg\,m/s + 60kg\,V_{2F}$$
$$-20kg\,m/s = 60kg\,V_{2F}$$
$$\frac{-20kg\,m/s}{60kg} = \boxed{-0.33\,m/s} = V_{2F}$$

b. $\vec{J}_1 = \Delta mV_1$
$= m_1(V_{1F} - V_{1i})$
$= 50kg(-2m/s - 6m/s)$
$= \boxed{-400\,kg\,m/s}$

$\vec{J}_2 = \Delta mV_2$
$= m_2(V_{2F} - V_{2i})$
$= 60kg(-0.33m/s - -7m/s)$
$= \boxed{400\,kg\,m/s}$

20.

$m_r = 25\,kg \quad X_r = 0.5\,m$

$m_b = 5.0\,kg \quad X_b = 1.0\,m$

$m_p = 1.0\,kg \quad X_p = 2.0\,m$

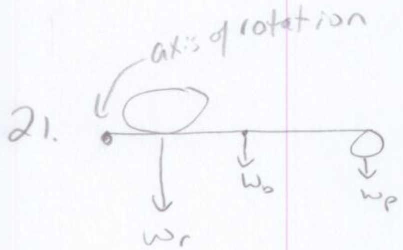
$$X_{CG} = \frac{X_r m_r + X_b m_b + X_p m_p}{m_r + m_b + m_p}$$

$$= \frac{0.5m\ 25kg + 1.0m\ 5.0kg + 2.0m\ 1.0kg}{25kg + 5.0kg + 1.0kg}$$

$$= \frac{12.5kgm + 5kgm + 2.0kgm}{31kg}$$

$$= \boxed{0.63m}$$ from left side or tree trunk.

21.



W_r = Weight of the racoon

$= m_r g = 25kg\ 9.8\,m/s^2$

$= 245N$

W_b = weight of the branch

$= m_b g = 5.0kg\ 9.8\,m/s^2$

$= 49N$

W_p = weight of the peach

$= m_p g = 1.0kg\ 9.8\,m/s^2$

$= 9.8N$

$$\Sigma \tau = \tau_r + \tau_b + \tau_p = 415\,Nm$$

$$= W_r X_r + W_b X_b + W_p X_p = 415\,Nm$$

$$= 245N\,X_r + 49N\ 1.0m + 9.8N\ 2.0m = 415\,Nm$$

$$245N\,X_r + 68.6\,Nm = 415\,Nm$$

$$245N\,X_r = 415Nm - 68.6Nm$$

$$X_r = \frac{346.4Nm}{245N}$$

$$\boxed{= 1.4m}$$

$\boxed{NO}$ he gets dumped on the ground!

However, so does the nice juicy peach :)