Exam 3
Phys 220- Fall 2013
Version B

Name: Solution Group: ______

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

2. What are the units of angular acceleration?
   a. Kilogram meter per second → mv → p
   b. Radians → θ
   c. Radians per second Rad/s → ω
   d. Radians per second per second Rad/s² → α
   e. Meters per second per second m/s² → a

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

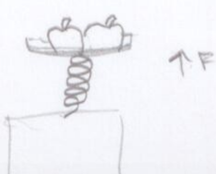
4. Momentum is conserved
   a. only if the collision is perfectly elastic
   b. only if the collision is perfectly inelastic
   c. if there is no outside force acting
   d. always
   e. other not listed above: ______________________________

5. 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 3.5 cm, what is the spring constant of the scale.
   a. -70 N/m
   b. 70 N/m
   c. 700 N/m
   d. -700 N/m

Cannot have a negative amount of stretchiness

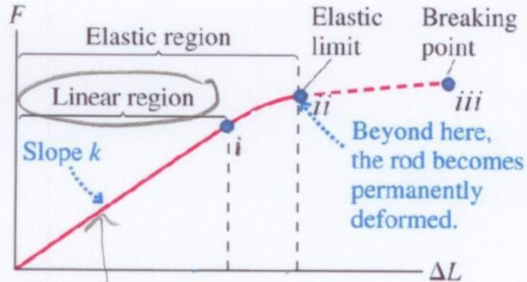
$F = -kx$

$$\frac{F}{-x} = k = \frac{2.5\,kg \; 9.8\,m/s^2}{-(-0.035\,m)} = 700\,N/m$$



Force from spring is up on apples displacement of the spring is negative.

6. 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 represent?
   a. Origin to point *iii*
   b. Origin to point *ii*
   c. Origin to point *i*
   d. Between *i* and *iii*.
   e. Between points *i* and *ii*



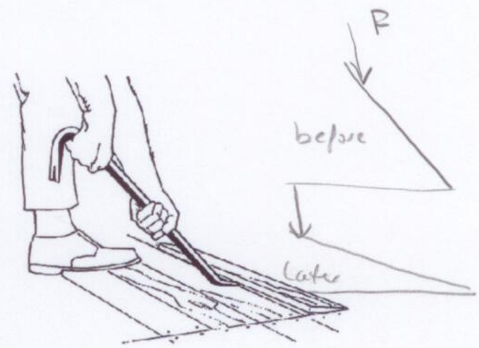
$F = -kx$

7. Why does the squishy interior of a ram's skull allow it to butt heads with another ram without causing a concussion?
   a. It spreads the force out over time
   b. it reduces the force
   c. it reduces the impulse
   d. it reduces the time of impact
   e. It spreads the force out over a larger area of the skull

$\vec{J} = F \cdot \Delta t = \Delta \vec{p}$

more time
less force → same impulse/change in momentum.

8. A man pushes straight down on the end of a crowbar in an attempt to lift a board off the floor. As the handle gets closer to the floor, is the man able to apply more or less torque with the same force?
   a. As the angle with the floor gets smaller, the torque stays the same.
   b. As the angle with the floor gets smaller, the torque decreases.
   c. As the angle with the floor gets smaller, the torque increases.



More of the force's perpendicular to the crowbar

9. Consider the happy/unhappy balls from class. They have identical size and mass. When the happy ball is dropped, it bounces, similar to a super ball. When the unhappy ball is dropped, it lands with a thud and does not bounce. When they are both dropped from the same height, the impulse delivered to the table by the happy ball is
   a. equal to the impulse delivered by the unhappy ball.
   b. less than the impulse delivered by the unhappy ball.
   c. greater than the impulse delivered by the unhappy ball.
   d. Not enough information

$\vec{J} = \Delta mv = m(v_f - v_i)$

If the ball doesn't bounce $v_f = 0$

If it does it is now a v in the opposite direction. A bigger change in v!

10. A person catches a 0.40 kg football that is traveling at 15 m/s. If the person feels a force of 15 N when they catch it, determine the time it took to bring the ball to rest.
   a. 0.20 s
   b. 0.40 s
   c. 0.50 s
   d. 1.0 s
   e. 1.8 s

$F \cdot \Delta t = \Delta mv$

$\Delta t = \dfrac{\Delta mv}{F} = \dfrac{0.40\,kg\,(0 - 15\,m/s)}{15\,N} = 0.40\,s$

11. A person runs up a set of stairs with a backpack on. The Achilles tendon compresses and stretches as they climb the stairs. Based on our model of stretching and compressing, where does the load in the backpack fit? The model is stress equals Young's modulus times the strain:

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

Stress = Y strain

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

Back pack is part of the Force on your achilles

A boy is sitting on the edge of a merry-go-round 2 m from the center, while his sister pushes it. The sister applies a Force of 250N for 1.5 seconds. If the merry-go-round started at rest, has no friction, and accelerates with an angular acceleration of 1.1 rad/s^2, $\alpha = 1.1\ \text{rad/s}^2$ $\Delta t = 1.5\text{s}$

12. What is the angular velocity at the end of the push?
   a. 3.3 rad/s
   b. 1.65 rad/s
   c. 1.23 rad/s
   d. 1.1 rad/s

$\omega_f = \omega_i + \alpha\Delta t$
$= 0\ \text{rad/s} + 1.1\ \text{rad/s}^2\ 1.5\text{s}$
$= \boxed{1.65\ \text{rad/s}}$

13. After 1 minute from the start of the push, what is the boy's angular displacement?
   a. 2000 rad
   b. 99 rad
   c. 98 rad
   d. 1.2 rad

part 1: $\theta_f = \theta_i + \omega_i\Delta t + \frac{1}{2}\alpha\Delta t^2$
$= 0 + 0 + \frac{1}{2}1.1\ \text{rad/s}^2(1.5\text{s})^2 = 1.23\ \text{rad}$
part 2: $\theta_f = 1.23\ \text{rad} + 1.65\ \text{rad/s}(58.5\text{s}) + 0 = 97.8\ \text{rad}$

14. The centripetal acceleration of the boy is
   a. Constant during the push
   b. Increasing during the push
   c. Decreasing during the push
   d. Not enough information

As he goes faster, the centripetal acceleration must be greater to keep him going in a circle. That is why it is much harder to hold on when the merry-go-round is going faster.

15. Determine the tangential acceleration of the boy during the push.
   a. 0 m/s^2
   b. 1.1 rad/s^2
   c. 1.4 m/s^2
   d. 2.2 m/s^2
   e. 5.45 m/s^2

$a_t = \alpha r = 1.1\ \text{rad/s}^2 \cdot 2.0\text{m} = 2.2\ \text{rad/s}^2$

16. How much torque does the girl apply to the merry-go-round during the push?
   a. 500 Nm
   b. 375 Nm
   c. 250 Nm
   d. Not enough information

$\tau = F_\perp \cdot r = 250\text{N} \cdot 2.0\text{m}$
$= 500\text{Nm}$

17. If, after his sister is done pushing and the merry-go round is traveling at a constant rate, the boy scoots in towards the center, the merry-go round will
    a. Keep spinning at the same rate
    b. Spin slower
    c. Spin faster
    d. Not enough information

Use conservation of angular momentum

$L = I\omega$

$I \sim \frac{1}{2}mr^2$ so $L = \frac{1}{2}mr^2\omega$ if $r\downarrow$ $\omega\uparrow$

18. If instead, after his sister is done pushing and the merry-go round is traveling at a constant rate, the boy jumps off, the merry-go-round will
    a. Keep spinning at the same rate
    b. Spin slower
    c. Spin faster
    d. Not enough information

Conservation of Angular momentum again

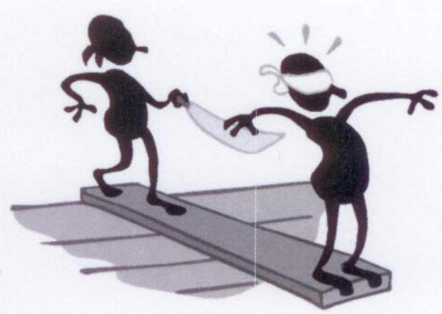
$L = \frac{1}{2}Mr^2\omega$

if $m\downarrow$ $\omega\uparrow$

Show all your work for credit on the following problems.

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. Their horns lock.
    a. Determine the final speed of the 60 kg Ram immediately after the collision.
    b. What is the impulse delivered to each Ram?

A 70kg pirate is threatening his 65kg captive at the end of a 2.5 meter, 18 kg, plank. The plank nails are getting loose and can only withstand a torque of 2500Nm.



20. As the pirate walks out onto the plank to nudge his captive off the end, how far can he move from the left end of the plank before he is also dumped into the water?

21. Find the center of mass of the plank, pirate, captive system when the pirate is only 0.5 m from the left edge of the plank and the captive is standing at the right end as shown above. Clearly define where you are measuring *from* (eg. Left end, right end, center…).

Version B

$m_1 = 50kg$

$m_2 = 60kg$

$V_{1i} = 6\,m/s$

$V_{2i} = ^-7\,m/s$

$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$

$50kg\ 6\,m/s + 60kg\ ^-7\,m/s = 110\,kg\,(V_f)$

$300kg\,m/s - 420\,kg\,m/s = 110\,kg\ V_f$

$\boxed{-1.1\,m/s = V_f}$

$\vec{J}_1 = \Delta m v_1$

$= 50kg\,(-1.1\,m/s - 6\,m/s)$

$= ^-355\,kg\,m/s$

$\boxed{-350\,kg\,m/s}$

$\vec{J}_2 = \Delta m v_2$

$= 60kg\,(-1.1\,m/s - -7\,m/s)$

$= 354\,kg\,m/s$

$\boxed{350\,kg\,m/s}$

Version A

$m_1 = 50kg$

$m_2 = 60kg$

$V_{1i} = 7\,m/s$

$V_{2i} = -6\,m/s$

$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$

$50kg\ 7\,m/s + 60kg\,^-6\,m/s = 110kg\,(V_f)$

$350kg\,m/s + -360\,kg\,m/s = 110kg\,(V_f)$

$\boxed{^-0.09\,m/s = V_f}$

$\vec{J}_1 = \Delta m v_1$

$= 50kg\,(-0.09\,m/s - 7\,m/s)$

$= \boxed{^-355\,kg\,m/s}$

$\vec{J}_2 = \Delta m v_2$

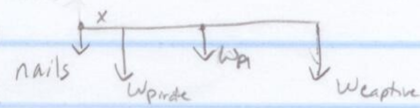
$= 60kg\,(-0.09\,m/s - -6\,m/s)$

$= \boxed{355\,kg\,m/s}$

Plank 2.5m

Version A

$\tau = W_p x + W_{pl}\, 1.25m + W_{cap}\, 2.5m = 2500Nm$

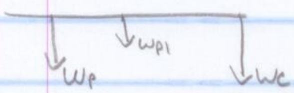


$70kg\, 9.8\frac{m}{s^2} x + 12kg\, 9.8\frac{m}{s^2}\, 1.25m + 60kg\, 9.8\frac{m}{s^2}\, 2.5m = 2500Nm$

$686x + 147Nm + 1470Nm = 2500Nm$

$686x + 1617Nm = 2500Nm$

$\boxed{x = 1.29m}$



$$X_{cg} = \frac{m_p x_p + m_{pl} x_{pl} + m_c x_c}{m_p + m_{pl} + m_c}$$

$$= \frac{70kg\, 0.5m + 12kg\, 1.25m + 60kg\, 2.5m}{70 + 12 + 60}$$

$$= \frac{35kgm + 15kgm + 150kgm}{142kg}$$

$$= \boxed{1.41\ m}$$ from left end

Version B

$\tau = W_p x + W_{pl}\, 1.25m + W_{cap}\, 2.5m = 2500Nm$

$= 70kg\, 9.8 m/s^2 x + 18kg\, 9.8 m/s^2\, 1.25m + 65kg\, 9.8 m/s^2\, 2.5m = 2500Nm$

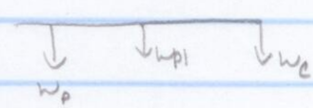
$= 686x + 220.5Nm + 1593Nm = 2500Nm$

$686x + 1813Nm = 2500Nm$

$x = \frac{687}{686}$

$= \boxed{1.00m}$

$$X_{cg} = \frac{70kg\, 0.5m + 18kg\, 1.25m + 65kg\, 2.5m}{153kg}$$



$= \frac{220}{153} = \boxed{1.44m}$ from the left end