Phys06 Fa24 LACC R. Erickson $\frac{80}{80}$ **Test 3** Ch7,8,9 Name KEY

Show enough work for FULL credit. Attach extra white paper as needed. For the multiple choice state a brief reason why you choose the answer you did to get full credit.

Chpt 7 Momentum

1. (5pts) The momentum of an isolated system is conserved

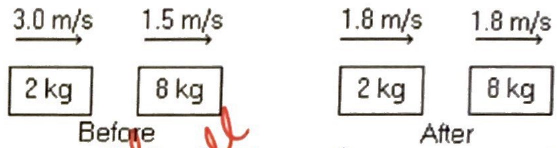
5

(a) in both elastic and inelastic collisions.
(b) only in inelastic collisions.
(c) only in elastic collisions.

Explain:

Cons. of momentum is universal

2. (5 pts) In the figure, determine the character of the collision. The masses of the blocks, and the velocities before and after, are shown. The collision is



5

(a) perfectly elastic.
(b) partially inelastic.
(c) completely inelastic.
(d) not possible because momentum is not conserved.

Explain:

equal for all cases

• sticks together

⇒ completely inelastic

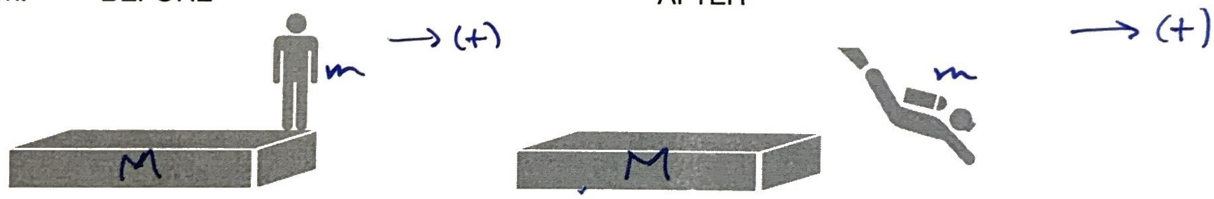
Momentum Before: $(3)(2)+(1.5)(8) = 6+12 = 18$

Momentum After: $(1.8)(2)+(1.8)(8) = 3.6+14.4 = 18$

checks to be ok data

3. (10 pts) A 60-kg swimmer suddenly dives horizontally from a 150-kg raft with a speed of 1.5 m/s. The raft is initially at rest. What is the speed of the raft immediately after the diver jumps if the water has negligible effect on the raft?

Diagram: BEFORE AFTER



momentum before = Momentum after

5

$V \cdot M + v \cdot m = V'M + v'm$

$0 + 0 = V'(150\text{kg}) + (1.5\text{m/s})(60\text{kg})$

5

$\Rightarrow$ $V' = \frac{(1.5)(60)}{150}$

$V' = -\frac{90}{150}$

$= -\frac{9}{15} = \frac{-3}{5} = \boxed{-0.6\text{ m/s}}$

20

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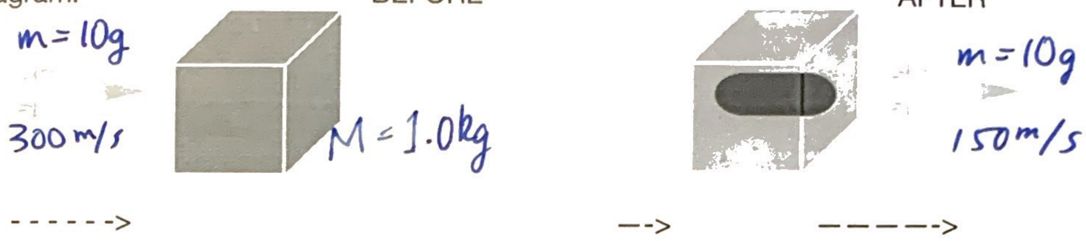
4. (10 pts) In a police ballistics test, a 10.0-g bullet moving at 300 m/s is fired into a 1.00-kg block at rest. The bullet goes through the block almost instantaneously and emerges with 50.0% of its original speed. What is the speed of the block just after the bullet emerges?

Diagram: BEFORE AFTER



momentum before = Momentum after

5 $mv + MV = mv' + MV'$ $V' = ?$

$(10g)300\,m/s + 0 = (10g)(150\,m/s) + (1000g)V'$

$3000\,g\cdot m/s - 1500\,g\cdot m/s = 1000g\,V'$

5 $\dfrac{1500\,g\cdot m/s}{1000\,g} = V'$

$\dfrac{15}{10}\,m/s = V'$

$\dfrac{3}{2}\,m/s = V'$

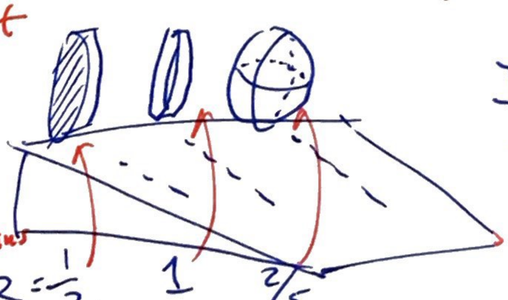
$\boxed{1.5\,m/s = V'}$

Chpt 8 Rotational Dynamics

5. (5 pts) A disk, a hoop, and a solid sphere are released at the same time at the top of an inclined plane. They are all uniform and roll without slipping. In what order do they reach the bottom? Why?

Object with most mass closest to the axis of rotation have more KE trans than K rot

(a) hoop, sphere, disk
(b) hoop, disk, sphere
(c)sphere, hoop, disk
(d) disk, hoop, sphere
(e) sphere, disk, hoop



$I = kmr^2$

$v = r\omega$

5 Explain:

PE = KE_{rot} + KE_{trans}

$k = \frac{1}{2}$ 1 $\frac{2}{5}$

(0.5) , (1.0) , (0.4)

$= \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2$

$= \frac{1}{2}kmr^2\left(\frac{v}{r}\right)^2 + \frac{1}{2}mv^2$

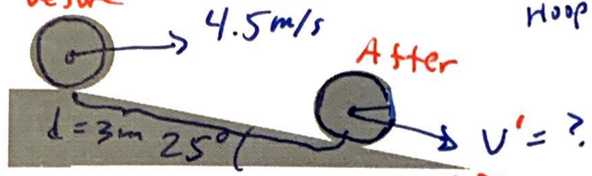
$= \frac{1}{2}mv^2[k+1]$

· sphere
· Disk
· Hoop

smallest Mom. of inertia

15 $\rightarrow \sqrt{\dfrac{mgh}{\frac{1}{2}m[k+1]}} = v \rightarrow \boxed{v = \sqrt{\dfrac{2h}{k+1}}} \Rightarrow$ Smallest divisor → largest speed

6. **(10 pts)** A hoop with a mass of 2.75 kg is rolling without slipping along a horizontal surface with a speed of 4.5 m/s when it starts down a ramp that makes an angle of 25° below the horizontal. What is the forward speed of the hoop after it has rolled 3.0 m down as measured along the surface of the ramp?



$m = 2.75\,kg$

Hoop $I = mr^2$

$v = \omega r$

$h = d\sin 25°$

Before	After
(PE + KE_{rot} + KE_{trans}) before	= (KE_{rot} + KE_{trans}) after

5 $$\boxed{mgh + \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2 = \frac{1}{2}I(\omega')^2 + \frac{1}{2}m(v')^2}$$ populate

5

$$mgd\sin\theta + \underbrace{\frac{1}{2}mr^2\left(\frac{v}{r}\right)^2 + \frac{1}{2}mv^2} = \underbrace{\frac{1}{2}mr^2\left(\frac{v'}{r}\right)^2 + \frac{1}{2}mv'^2}$$

$$\cancel{m}gd\sin\theta + \cancel{m}v^2 = \cancel{m}v'^2$$

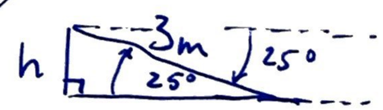
$$\sqrt{v^2 + gd\sin\theta} = v'$$

$$\sqrt{(4.5\,m/s)^2 + (9.8\,m/s^2)(3m)\sin 25°} = v'$$

$$\sqrt{32.67} = v'$$

$$\boxed{5.72\,m/s = v'}$$

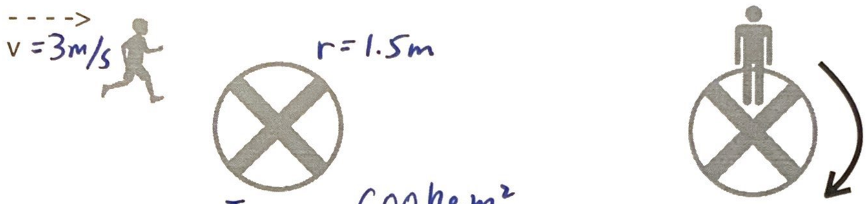
5.7 m/s



$3 \cdot \sin 25 = 1.268\,m$

10

7. (10 pts) A 40.0-kg child running at 3.00 m/s suddenly jumps onto a stationary playground merry-go-round at a distance 1.50 m from the axis of rotation of the merry-go-round. The child is traveling tangential to the edge of the merry-go-round just before jumping on. The moment of inertia about its axis of rotation is 600 kg · m^2 and very little friction at its rotation axis. What is the angular speed of the merry-go-round just after the child has jumped onto it?



$I_{mgr} = 600\,kgm^2$

$L = I\omega$

$I_c = mr^2$

$\omega' = ?$

angular Momentums before = Momentums after

$$\boxed{L_{child} + L_{mGR} = L_{child} + L_{mgr}}$$

4

$$rp + \cancel{I\omega}^{\,0} = (mr^2)\omega' + I\omega'$$

6

$$\frac{rp}{I + mr^2} = \omega'$$

$$\frac{(1.5m)(40kg)(3m/s)}{600kgm^2 + 40kg(1.5m)^2} = \omega'$$

$$\frac{180\ kgm^2/s}{690\ kg \cdot m^2} = \omega'$$

$$\boxed{0.26\ rad/s = \omega'}$$

FYI:
$(0.26\,r/s)\left(\frac{1\,rev}{2\pi\,r}\right) = 0.0415$ rps

$= \left(0.0415\,\frac{rev}{s}\right)\left(\frac{60s}{min}\right) = \underline{2.5\,rpm}$

Chpt 9 Statics and Elasticity

8. (5 pts) A large 75-kg lighting fixture can be hung from wires of identical size and shape made of aluminum, brass, or copper. The values of Young's modulus for these metals are 0.70 × 10^{11} Pa (aluminum), 0.91 × 10^{11} (brass), and 1.1 × 10^{11} (copper). Which wire would stretch the *most* distance?

5

(a) aluminum
(b) brass
(c) copper
(d) They will all stretch the same distance.

Explain:

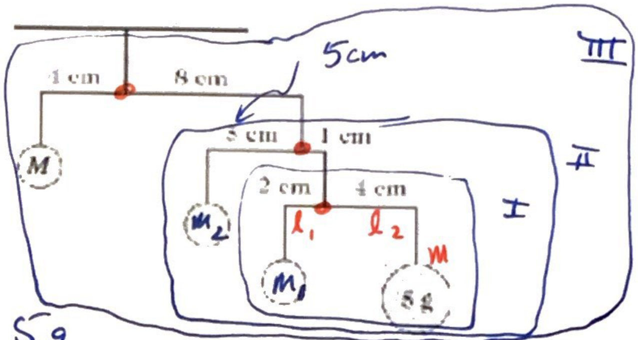
$$Y = \frac{stress}{strain} \Rightarrow Y = \frac{F/A}{\Delta l / l} \Longrightarrow \Delta l = \frac{F \cdot l}{A \cdot Y}$$

So Aluminum, b/c has the smallest Y

the smaller Y the Larger Δl

15

9. (10 pts) A mobile is shown in the figure. The horizontal supports have no mass. Assume that all the numbers given in the figure are accurate to two significant figures. What mass *M* is required to balance the mobile? Start balancing from the bottom and work up to find the missing masses.



l_1 l_2

m_1 m_2

$\sum \tau = 0$ at each intersection

$-l_A m_A + l_B m_B = 0$

10

so $m_A = \left(\frac{l_B}{l_A}\right) m_B$

I 3 Bottom

$m_1 = \frac{4cm \cdot 5g}{2cm} = \underline{10g}$

II 3

$m_2 = \frac{1cm \cdot (10+5)}{5cm}$ middle

$m_2 = \frac{1cm \cdot 15}{5cm} = \underline{3g}$

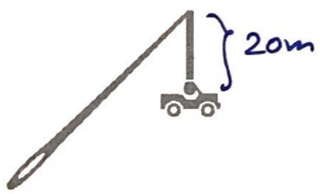
III 4

$M = \frac{8cm \cdot (5+10+3)}{4cm}$ Top

$M = \frac{8cm \cdot 18}{4cm} = 2 \cdot 18 = \underline{36g}$ ✓

10. (10 pts) A 1200-kg car is being raised with a constant acceleration of 2.53 m/s^2 by a crane, using a 20-m long steel cable that is 1.5 cm in diameter. Young's modulus for steel is 2.0 × 10^{11} N/m^2. What is the change in length of the cable caused by lifting the car?

5



Part I: $F_T = Ma + Mg$

$F_{Tension} = (1200kg)(2.53 m/s^2) + (1200kg)(9.8 m/s^2)$

$= 1200 (12.33 m/s^2)$

$= \boxed{14,796 N}$

Part II: Stress / Strain = Y { Solve for ΔL }

$Y = \frac{F_T/A}{\Delta l / l}$

5 $\Delta l = \frac{F_T \cdot l}{Y \cdot A}$

$\Delta l = \frac{[14,796 N](20m)}{\left(2 \times 10^{11} \frac{N}{m^2}\right)\left(\pi \left[\frac{0.015m}{2}\right]^2\right)}$

20 $\Delta l = 0.0084m$ or $\boxed{8.4mm}$ 8.4 mm

EQUATIONS

Chpt 2-3

ave vel: $\bar{v} = \frac{\Delta x}{\Delta t}$

ave acc'ln: $\bar{a} = \frac{\Delta v}{\Delta t}$

1-Dim

$$v = v_0 + at$$

$$x = x_0 + v_0 t + \frac{1}{2}at^2$$

$$v_f^2 = v_0^2 + 2a\Delta x$$

$$\bar{v} = \frac{v + v_0}{2}$$

2-Dim

x-comp	y-comp't.
$v_x = v_{0x} + a_x t$	$v_y = v_{0y} + a_y t$
$x = x_0 + v_{0x} t + \frac{1}{2}at^2$	$y = y_0 + v_{0y} t + \frac{1}{2}at^2$
$v_{fx}^2 = v_{0x}^2 + 2a\Delta x$	$v_{fy}^2 = v_{0y}^2 + 2a\Delta y$
$\bar{v}_x = \frac{v_x + v_{0x}}{2}$	$\bar{v}_y = \frac{v_y + v_{0y}}{2}$

- Range Eqn: $R = \frac{v_0^2 \sin 2\theta}{g}$
- Time of Flight from ground to ground: $t = \frac{2v_{0y}}{g}$
- Hieght Eqn: $H = \frac{v_{0y}^2}{2g}$
- Relative Velocity:

$$\sin\theta = \frac{V_{\text{Water w.r.t. shore}}}{V_{\text{Boat wrt. water}}}$$

EQUATIONS

(Chpt 4,5,6)

Newt's Laws: $\sum F_x = ma_x$, $F_{spring} = -k\Delta x$

$\sum F_y = ma_y$

Friction: $f = \mu N$

Centripetal acc'ln: $a = \frac{V_{Tan}^2}{R}$, $V_{Tan} = \frac{2\pi R}{T}$, $f = \frac{1}{T}$ frequency

Gravitation: $F = G\frac{Mm}{R^2}$, $T^2 = \frac{4\pi^2}{GM} r^3$

Work: $W = Fd\cos\theta$

$KE = \frac{1}{2}mv^2$, $PE_{grav} = mgh$, $PE_{spring} = \frac{1}{2}k\Delta x^2$

$PE_1 + KE_1 + W_{applied} = PE_2 + KE_2$

Power: $P = \frac{Energy}{time}$, Efficiency: $e = \frac{P_{out}}{P_{in}}$

$P = \frac{W}{t} = \frac{Fd}{t} = F\bar{v}$

$M_{moon} = 7.35 \times 10^{22}$ kg, $G = 6.67 \times 10^{-11}$ Nm^2/kg^2

$M_{earth} = 5.972 \times 10^{24}$ kg

add Bank curve

EQUATIONS

- Ch7 Momentum

$$\vec{p} = m\vec{v}, \quad \sum \vec{F} = \frac{\Delta \vec{p}}{\Delta t}, \quad m_A\vec{V}_A + m_B\vec{V}_B = m_A\vec{V}_A' + m_B\vec{V}_B'$$

$$\text{impulse} = \vec{F}\Delta t = \Delta\vec{p}$$

$$V_A - V_B = -(V_A' - V_B') \Leftarrow \text{1-Dim elastic} \Rightarrow \tfrac{1}{2}m_AV_A^2 + \tfrac{1}{2}m_BV_B^2 = \tfrac{1}{2}m_AV_A'^2 + \tfrac{1}{2}m_BV_B'^2$$

$$\text{CM}: \quad X_{cm} = \frac{m_A X_A + m_B X_B + \cdots}{m_A + m_B + \cdots}$$

- Ch8 Rotational Motion $\omega = \frac{\Delta\theta}{\Delta t}$, $\alpha = \frac{\Delta\omega}{\Delta t}$

$x = x_0 + V_{0x}t + \frac{1}{2}at^2$	$x = r\theta$	$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$
$V = V_0 + at$	$V = r\omega$	$\omega = \omega_0 + \alpha t$
$V_f^2 = V_0^2 + 2ax$	$a_T = r\alpha$	$\omega_f^2 = \omega_0^2 + 2\alpha\theta$
$F = ma$	$\tau = rF\sin\theta$	$\tau = I\alpha$
$p = mV$	$L = pr$	$L = I\omega$
$KE = \frac{1}{2}mv^2$	$I = mr^2$	$KE = \frac{1}{2}I\omega^2$
$W = Fd$	$a_R = \frac{V^2}{r}$	$W = \tau\theta$
$F = \frac{\Delta p}{\Delta t}$		$\tau = \frac{\Delta L}{\Delta t}$

$$\omega = 2\pi f = \frac{2\pi}{T}$$

I: $I = kmr^2$

Hoop $k = 1$

$\frac{1}{12}Ml^2$

puck $k = \frac{1}{2}$

$\frac{1}{3}Ml^2$

solid sphere $k = \frac{2}{5}$

Energy Balance with Work:
E_{TOT} befor $= E_{TOT}$ after, where
E = work done by friction + KE_{linear} + KE_{rot} + PE

Ch 9 Statics and Elasticity

$$\sum F_x = 0, \quad \sum F_y = 0, \quad \sum \tau = 0$$

$$\text{Modulus of Elasticity} = \frac{\text{stress}}{\text{strain}}$$

1-D: stress $= F/A$, strain $= \Delta\ell/\ell$

2-D: stress (shear) $= F/A$, strain (deflection) $= \Delta\ell/\ell$ $\perp$

3-D: stress $= P$; strain $= \Delta V/V_0$