Gen Phys I Quiz 3 - OS Chs. 8,9,10,11 - Momentum, Equilibrium, Rotation, Fluids 3/30/23

Rec. Time: Name:

For full credit, make your work clear. Show formulas used, essential steps, and results with correct units and significant figures. Points shown in parenthesis. For TF and MC, choose the *best* answer.

1. (3) Which of the following are equal to the change in momentum of a mass? Check all that apply.

a. $m\,\Delta\mathbf{v}$. b. $\mathbf{F}\,\Delta t$. c. $\frac{1}{2}mv^2$. d. $\mathbf{F}\cdot\mathbf{d}$.

2. (3) While a bullet moving towards north is slowing down while flying straight into a block of wood, the direction of the impulse on the bullet is closest to

a. north. b. south. c. east. d. west. e. upward. f. downward.

3. (3) If there are no external forces on a pair of colliding masses,

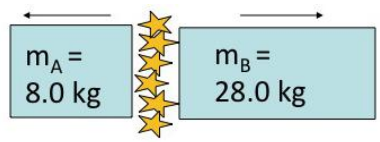
a. their total energy will be conserved. b. their accelerations will be equal and opposite.
c. their total momentum will be conserved. d. the net force on each mass will be zero.

4. (2) **T F** While a projectile is being propelled out of a weapon, its momentum is conserved.

5. (2) **T F** Total kinetic energy is conserved in an elastic collision.

6. (2) **T F** The momentum change of a mass equals the product of the average net force acting on it and the time that the force acts.

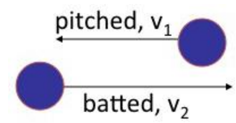
7. (12) Due to an explosion, a 36.0-kg mass initially at rest splits into a 28.0 kg piece that acquires 4.80 kJ of kinetic energy and a 8.0 kg piece flying away in the opposite direction.



a) (6) How fast is the 28.0 kg piece moving just after the explosion?

b) (6) How much kinetic energy does the 8.0-kg mass acquire right after the explosion?

8. (8) A 145-gram baseball is hit by the batter and changes velocity from 18.0 m/s south to 42.0 m/s north over 5.0 ms. How large was the average force of impact of the bat on the ball?



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9. (2) **T F** In a collision of two objects, each one receives the same (vector) change in momentum.

10. (2) **T F** If the duration of a collision is extended, the average force between the objects is reduced.

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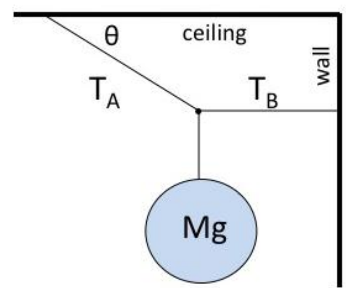
11. (12) A lighting fixture weighing $Mg = 155$ N is suspended by cables connected to the wall and ceiling as shown, where the upper cable with tension T_A makes an angle $\theta = 35.0°$ to the ceiling.



a) (6) Find the tension T_A in the cable connected to the ceiling.

b) (6) Find the tension T_B in the cable connected to the wall.

12. (6) Consider solid 1.0 cm^3 samples of gold (19.3 g/cm^3), silver (10.5 g/cm^3), and aluminum (2.70 g/cm^3).

a) (3) Which one weighs the most?

a. The gold. b. The silver. c. The aluminum. d. All tie.

b) (3) Which one experiences the largest buoyant force when totally submerged under water?

a. The gold. b. The silver. c. The aluminum. d. All tie.

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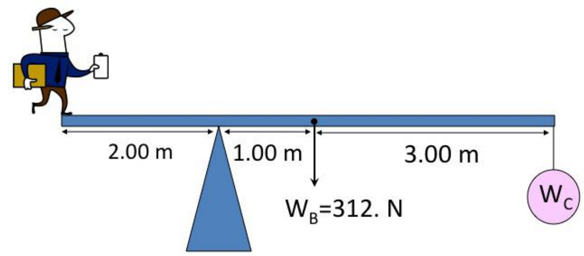
13. (18) A centrifuge requires an average torque of 45 N·m acting for 6.5 s to get to its operating speed of 18600 rpm. It spins blood samples in a circle of radius 8.0 cm.

a) (6) While at operating speed, what centripetal acceleration in g's does the blood experience?

b) (6) How large is the rotational inertia of the centrifuge?

c) (6) While at its operating speed, how large is the rotational kinetic energy?

14. (8) A worker is standing at the end of a uniform beam of weight $W_B = 312$ N, balanced on a pivot. A counterweight $W_C = 365$ N is hanging at the opposite end of the beam. How much does the worker weigh?



15. (2) **T F** Forces due to static pressure in a fluid point parallel to the container's surfaces.

16. (2) **T F** When an object sinks in a fluid, the buoyant force on it is less than its weight.

17. (2) **T F** When an object floats on a fluid, the buoyant force on it is more than its weight.

18. (6) An 85-kg athlete's foot has a bottom surface area of about 8 cm $\times$ 22 cm. If he stands still on one foot, what pressure in pascals does that produce under that foot?

19. (8) Sea water has a density of 1025 kg/m^3. One day, the air pressure at the ocean surface is 105 kPa. How deep under the surface will the absolute pressure be 10.0 atm?

Prefixes

a=10^{-18}, f=10^{-15}, p=10^{-12}, n=10^{-9}, $\mu = 10^{-6}$, m=10^{-3}, c=10^{-2}, k=10^{3}, M=10^{6}, G=10^{9}, T=10^{12}, P=10^{15}.
atto, femto, pico, nano, micro, milli, centi, kilo, mega, giga, tera, peta.

Physical Constants

$g = 9.80$ m/s^2 (gravitational acceleration)
$M_E = 5.98 \times 10^{24}$ kg (mass of Earth)
$m_e = 9.11 \times 10^{-31}$ kg (electron mass)
$c = 299792458$ m/s (exact speed of light)
$G = 6.67 \times 10^{-11}$ N·m^2/kg^2 (Gravitational constant)
$R_E = 6380$ km (mean radius of Earth)
$m_p = 1.67 \times 10^{-27}$ kg (proton mass)

Units and Conversions

1 inch = 1 in = 2.54 cm (exact)
1 mile = 5280 ft (exact)
1 m/s = 3.6 km/hour (exact)
1 acre = 43560 ft^2 = (1 mile)^2/640 (exact)
1 foot = 1 ft = 12 in = 30.48 cm (exact)
1 mile = 1609.344 m = 1.609344 km (exact)
1 ft/s = 0.6818 mile/hour
1 hectare = 10^4 m^2 (exact)

Trig summary

$\sin\theta = (\text{opp})/(\text{hyp})$, $\cos\theta = (\text{adj})/(\text{hyp})$, $\tan\theta = (\text{opp})/(\text{adj})$, $(\text{opp})^2 + (\text{adj})^2 = (\text{hyp})^2$.
$\sin\theta = \sin(180^\circ - \theta)$, $\cos\theta = \cos(-\theta)$, $\tan\theta = \tan(180^\circ + \theta)$, $\sin^2\theta + \cos^2\theta = 1$.

OpenStax Ch. 2: 1D Kinematics

$\bar{v} = \Delta x/\Delta t$, $\Delta x = x - x_0$, slope of $x(t)$ curve $= v(t)$.
$\bar{a} = \Delta v/\Delta t$, $\Delta v = v - v_0$, slope of $v(t)$ curve $= a(t)$.

Quadratic eqn.: $ax^2 + bx + c = 0$.
Solution: $x = \left[-b \pm \sqrt{b^2 - 4ac}\,\right]/(2a)$.

For constant acceleration in one-dimension:

$\bar{v} = \frac{1}{2}(v_0 + v)$, $v = v_0 + at$, $x = x_0 + v_0 t + \frac{1}{2}at^2$, $v^2 = v_0^2 + 2a(x - x_0)$.

OpenStax Ch. 3: 2D & 3D Motion

Vectors written $\vec{V}$ or $\mathbf{V}$, described by magnitude=V, direction=θ or by components (V_x, V_y).

$V_x = V\cos\theta$, $V_y = V\sin\theta$,

$V = \sqrt{V_x^2 + V_y^2}$, $\tan\theta = V_y/V_x$. θ is the angle from $\vec{V}$ to x-axis.

Addition: $\mathbf{A} + \mathbf{B}$, head to tail. Subtraction: $\mathbf{A} - \mathbf{B}$ is $\mathbf{A} + (-\mathbf{B})$, $-\mathbf{B}$ is $\mathbf{B}$ reversed.

OpenStax Chs. 4 & 5: Newton's Laws & Friction

Newton's Second Law:

$\vec{F}_{\text{net}} = m\vec{a}$, means $\Sigma F_x = ma_x$ and $\Sigma F_y = ma_y$. $\vec{F}_{\text{net}} = \sum \vec{F}_i$, sum over all forces on a mass.

Gravitational force ($F_g = mg$) components on inclines:

$F_{g\parallel} = mg\sin\theta$, $F_{g\perp} = mg\cos\theta$, for incline at angle θ to horizontal.

Friction magnitude (opposes the relative motion of two surfaces):

$f_s \le \mu_s N$ (static friction). $f_k = \mu_k N$ (kinetic or sliding friction).

OpenStax Ch. 6: Circular Motion

Centripetal Acceleration:

$a_c = v^2/r = \omega^2 r$, towards the center of the circle. Use ω in rad/sec!

Circular motion:

speed $v = 2\pi r/T = 2\pi r f$, frequency $f = 1/T$, where T is the period of one revolution.
speed $v = \omega r$, angular speed $\omega = 2\pi f = 2\pi/T$, ω is in rad/sec.

OpenStax Ch. 7: Work & Energy

Work & Kinetic & Potential Energies: $F_{\text{gravity},y} = -mg$, $F_{\text{spring}} = -kx$.

$W = Fd\cos\theta$, $\text{KE} = \frac{1}{2}mv^2$, $\text{PE}_{\text{gravity}} = mgy$, $\text{PE}_{\text{spring}} = \frac{1}{2}kx^2$. θ = angle btwn $\vec{F}$ and $\vec{d}$.

Conservation or Transformation of Energy:

Work-KE theorem:

$\Delta\text{KE} = W_{\text{net}}$ = work of all forces.

General energy-transformation law:

$\Delta\text{KE} + \Delta\text{PE} = W_{\text{NC}}$ = work of non-conservative forces.

Power:

$P_{\text{ave}} = W/t$, or use P_{ave} = energy/time.

OpenStax Ch. 8: Momentum

Momentum & Impulse:

momentum $\vec{p} = m\vec{v}$, impulse $\Delta\vec{p} = m\Delta\vec{v} = \vec{F}_{\text{ave}}\,\Delta t$.

Conservation of Momentum:

(2-body collision): $m_A\vec{v}_A + m_B\vec{v}_B = m_A\vec{v}_A^{\,\prime} + m_B\vec{v}_B^{\,\prime}$.

1D elastic collision–conservation of energy:

$\frac{1}{2}m_Av_A^2 + \frac{1}{2}m_Bv_B^2 = \frac{1}{2}m_Av_A'^2 + \frac{1}{2}m_Bv_B'^2$, or $v_A - v_B = -(v_A' - v_B')$.

OpenStax Ch. 9: Rotational Motion

Rotational coordinates:

1 rev = 2π radians = $360°$, $\omega = 2\pi f$, $f = \frac{1}{T}$, $\bar{\omega} = \frac{\Delta\theta}{\Delta t}$, $\bar{\alpha} = \frac{\Delta\omega}{\Delta t}$, $\Delta\theta = \bar{\omega}\Delta t$.

Linear coordinates vs. rotation coordinates and radius:

$l = \theta r$, $v = \omega r$, $a_{\tan} = \alpha r$, $a_c = \omega^2 r$, (must use radians in these).

Constant angular acceleration:

$\omega = \omega_0 + \alpha t$, $\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$, $\bar{\omega} = \frac{1}{2}(\omega_0 + \omega)$, $\omega^2 = \omega_0^2 + 2\alpha\Delta\theta$.

Torque & Dynamics:

$\tau = rF\sin\theta$, $I = \Sigma mr^2$, $\tau_{\text{net}} = I\alpha$, $L = I\omega$, $\Delta L = \tau_{\text{net}}\Delta t$, $\text{KE}_{\text{rotation}} = \frac{1}{2}I\omega^2$.

Rotational Inertias about centers:

$I = MR^2$,	$I = \frac{1}{2}MR^2$,	$I = \frac{2}{5}MR^2$,	$I = \frac{1}{12}ML^2$.
hoop	solid cylinder	sphere	thin rod

OpenStax Ch. 10: Static Equilibrium

$\Sigma F_x = \Sigma F_y = \Sigma F_z = 0$, $\Sigma\tau = 0$, $\tau = rF\sin\theta = r_\perp F = rF_\perp$, τ=torque around a chosen axis.

OpenStax Ch. 11: Static Fluids

Density:

$\rho = m/V$, SG=ρ/ρ_{H_2O}, $\rho_{H_2O} = 1000\ \text{kg/m}^3 = 1.00\ \text{g/cm}^3$ (at 4°C).

Static Fluids:

$P = F/A$, $P_2 = P_1 + \rho gh$, $\Delta P = \rho gh$, $P = P_{\text{atm.}} + P_G$, $B = \rho gV$ or $F_B = \rho gV$.

Pressure Units:

1 Pa = 1 N/m^2, 1 bar = 10^5 Pa = 100 kPa, 1 mm-Hg = 133.3 Pa.

1.00 atm = 101.3 kPa = 1.013 bar = 760 torr = 760 mm-Hg =14.7 lb/in^2.