ID: C **Name:** KEY

Exam 3 **16 Questions**

Multiple Choice
Identify the choice that best completes the statement or answers the question.

____ 1. When the sum of the external forces and the sum of the external torques on a body are both zero, we can conclude that

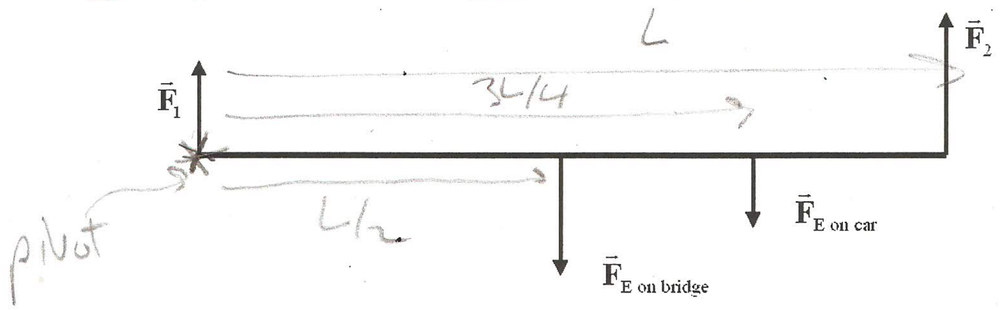
$\sum\vec{\tau} = I\vec{\alpha}$ $\sum\vec{F} = m\vec{a}$ 0 0

a. the body has neither linear nor angular velocity.
b. the body may have constant linear or constant angular $\boxed{\text{velocity,}}$ or both simultaneously.
c. the body may have constant linear or angular velocity, but not both simultaneously.
d. the body is rotating at constant angular velocity but has no linear velocity.
e. the body is moving at constant velocity but is not rotating.

____ 2. When two bodies of different masses collide, the impulses they exert on each other are
a. equal but opposite only for inelastic collisions.
b. equal but opposite only for elastic collisions.
c. equal for all collisions.
d. equal but opposite for all collisions. Newton's 3rd Law
e. equal but opposite only when the bodies have equal but opposite accelerations.

____ 3. The free body diagram below represents a 1 500 kg car sitting on a 3 000 kg bridge supported at its far ends. The car's position is three quarters of the length L from the left end of the bridge. Identify the one error in the torque equation below:

NO. $\cancel{F_1 L} - F_{\text{E on bridge}}(L/2) - F_{\text{E on Car}}(3L/4) + F_2 L = 0$ $\sum\tau = 0$



a. $\vec{F}_2$ never produces a torque on the bridge no matter where the axis of rotation is placed.
b. $\vec{F}_1$ never produces a torque on the bridge no matter where the axis of rotation is placed.
c. Because the perpendicular distance to $\vec{F}_2$ from the right end of the bridge is 0, F_2L should be 0.
d. Because the perpendicular distance to $\vec{F}_1$ from the left end of the bridge is 0, F_1L should be 0.
e. $\vec{F}_{\text{E on bridge}}$ cannot produce a torque on the bridge no matter where the axis of rotation is taken since it is at the center of the bridge.

____ 4. Some species of whales can dive to depths of one kilometer. What is the absolute pressure they experience at this depth? (ρ_{sea} = 1 020 kg/m^3 and 1.01 × 10^5 N/m^2 = 1 ATM. This is your unit conversion from pascals to atmospheres.)

a. 90.0 ATM
b. 111 ATM
c. 100 ATM ✓
d. 130 ATM
e. 9.00 ATM

$P = P_{ATM} + \rho g h = 1.01\times10^5 + 1020(9.8)(1000)$

$= 1.0097\times10^7 \times \frac{1\,ATM}{1.01\times10^5\,pa} = 100\,ATM$

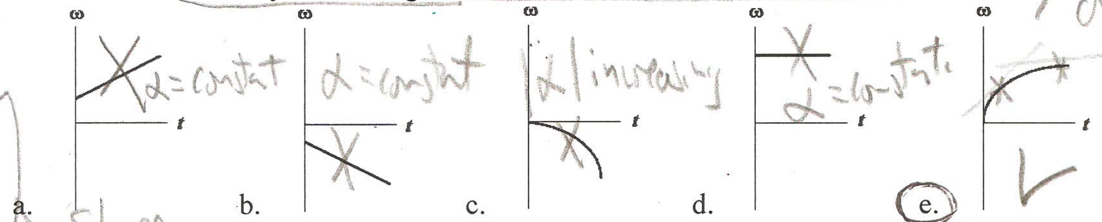
____ 5. The graphs below show angular velocity as a function of time. In which one is the magnitude of the angular acceleration constantly decreasing?

decreasing

$\omega = \frac{d\theta}{dt}$

$\boxed{\alpha = \frac{d\omega}{dt}}$

slope



a. b. c. d. e. ✓

____ 6. An object of mass *m* is suspended by two coplanar wires, as shown below. What is the magnitude of the tension in each wire?

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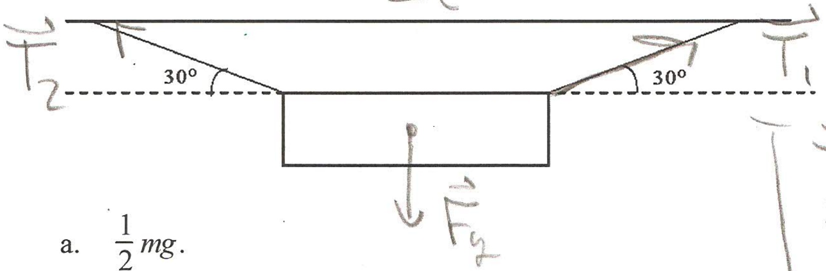


Symmetry ⇒ $|\vec{T}_1| = |\vec{T}_2| = T$
(or î of 2nd)

$\vec{T}_1 = T\cos(30)\hat{i} + T\sin(30)\hat{j}$
$\vec{T}_2 = -T\cos(30)\hat{i} + T\sin(30)\hat{j}$
$\vec{F}_g = -mg\hat{j}$

a. $\frac{1}{2}mg$.
b. $\frac{\sqrt{2}}{2}mg$.
c. $\sqrt{2}mg$.
d. $\frac{\sqrt{3}}{2}mg$.
e. mg. ✓

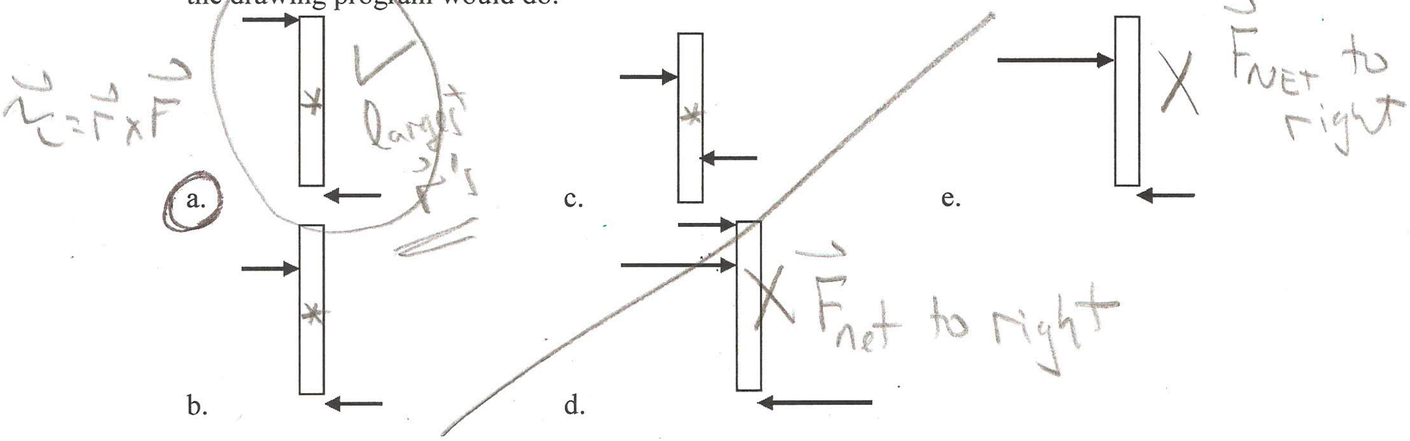
2nd $\boxed{\hat{j}}$ $\sum F_j = 0$

$\therefore 2T\sin(30) = mg$

$T = \frac{mg}{2\sin(30)} = mg$ ☺

OVER →

____ 7. Which of the following diagrams shows the greatest magnitude net torque with a zero net force? All the rods are of length (2r) and rotate about an axis that is at the center of the rod and coming out of the page. All the forces are of magnitude (F) or ($2F$) as indicated by the length of the arrows. All of the distances from the axis of rotation are (r) or ($r/2$) as shown in the figures. Some of the forces might look as if they are not applied to the rod, but they are applied and at the distances indicated in the previous sentance. This is the best the drawing program would do.



____ 8. Air within the funnel of a large tornado may have a pressure of only 0.2 ATM. What is the approximate outward force on a (5 m × 10 m) wall if a tornado suddenly envelops the house? Note that the pressure inside the house is one atmosphere. (1 ATM = 1.01 × 10^5 N/m².)

a. 4×10^4 N
b. 4×10^5 N
c. 4×10^6 N
d. 7×10^5 N
e. 4×10^3 N

$P_{net} = P_{inside} - P_{outside} = 0.8\,ATM = 80800$ pa

$\therefore F_{net} = P_{net} * A = 80800 * 5 * 10 = 4.04 \times 10^6$ N

____ 9. A Boeing 737 airliner has a mass of 20 000 kg. The total surface area of the tops of the wings is 100 m². Just to be clear, that means that the total surface area of the bottoms of the wings is also 100 m². What is the pressure difference on the wings when the airplane is in flight at a constant altitude?

a. 3 920 N/m²
b. 3 070 N/m²
c. 1 960 N/m²
d. 7 840 N/m²
e. 4 560 N/m²

$\vec{F}_{lift} = +F_{lift}\hat{j}$

$\vec{F}_g = -mg\hat{j}$

$\sum \vec{F} = 0$

$\Delta P = \frac{F_{lift}}{A} = \frac{mg}{100} = 1960$ pa

____ 10. At $t = 0$, a wheel rotating about a fixed axis at a constant angular acceleration has an angular velocity of 2.0 rad/s. Two seconds later it has turned through 5.0 complete revolutions. What is the angular acceleration of this wheel? (1 revolution = 2π radians)

0 (a choice)

a. 23 rad/s²
b. 14 rad/s²
c. 20 rad/s²
d. 17 rad/s²
e. 13 rad/s²

$\theta(t) = \cancel{\theta_0} + \omega_0 t + \frac{1}{2}\alpha t^2 = 2t + \frac{1}{2}\alpha t^2$ $\boxed{1}$

$\omega(t) = \omega_0 + \alpha t = 2 + \alpha t$ $\boxed{2}$

@ $t = 2$, $\theta = 5 * (2\pi)$, $\omega_2 = ?$

$\boxed{1} \rightarrow 10\pi = 2(2) + \frac{1}{2}\alpha(2)^2$

$\therefore \alpha = 13.7$ rad/s²

for block $\vec F_{buoyant}$ $\vec T = +W\hat j$ $\vec F_g$ 2nd $\sum F_y = 0$

$\therefore W = F_g - F_{buoyant} = mg - m_w g$

____ 11. An iron block of density ρ_{Fe} and of volume l^3 is immersed in a fluid of density ρ_{fluid}. The block hangs from a scale which reads W as the weight. The top of the block is a height h below the surface of the fluid. The correct equation for the reading of the scale is ______.

a. $W = (\rho_{Fe} + \rho_{fluid})ghl^2$.
b. $W = (\rho_{fluid} - \rho_{Fe})gl^3$.
c. $W = (\rho_{Fe} - \rho_{fluid})ghl^2$.
d. $\boxed{W = (\rho_{Fe} - \rho_{fluid})gl^3}$.
e. $W = (\rho_{Fe} + \rho_{fluid})gl^3$.

$V_{block} = V_{water\ displaced}$, l^3

$W = \rho_{Fe} V g - \rho_w V_w g$

$W = l^3 g(\rho_{Fe} - \rho_w)$

____ 12. A large water storage container is filled to a depth of 3.0 m. The volume above the water is filled with air. In order to pump the water from the container, the air pressure in the container is increased by 3.0×10^5 N/m². What happens to the pressure in the water at a depth of 1.0 m when the air pressure is increased?

a. It increases by 2.0×10^5 N/m², since it is at 2/3 the depth from the bottom of the container.
b. It increases by 3.0×10^5 N/m² + 9.8×10^3 N/m² since it is 1.0 m deep in the water.
c. Nothing, it is still at a depth of 1.0 m and the pressure in the water depends only on the depth.
d. It increases by 1.0×10^5 N/m², since it is at 1/3 the depth of the water.
e. $\boxed{\text{It increases by } 3.0 \times 10^5 \text{ N/m}^2.}$

Pascal: * "... transferred undiminished..."

* $P = \boxed{P_0} + \rho g h$

____ 13. A supertanker filled with oil has a total mass of 6.1×10^8 kg. If the dimensions of the ship are those of a rectangular box 300 meters long, 80 meters wide, and 40 meters high, determine how far the bottom of the ship is below sea level. (ρ_{sea} = 1 020 kg/m³.)

a. 15 m
b. 25 m ✓
c. 10 m
d. 20 m
e. 30 m

$\vec F_{buoyant}$, $\vec F_g$, $\sum F_y = 0$

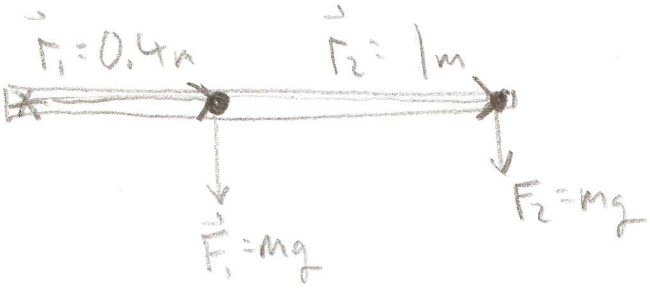
$\therefore (\rho_{sw} V_{displaced})g = M_{ship}\, g$

$\rho_{sw}(300 * 80 * d) = M_{ship}$

$d = 24.9$ meters

____ 14. Particles (mass of each = 0.20 kg) are placed at the 40-cm and 100-cm marks of a meter stick. The mass of the meter stick is very small and can be ignored. This rigid body is free to rotate about a frictionless pivot at the 0-cm end. The body is released from rest in the horizontal position. What is the initial angular acceleration of the body? I_{rod} about an axis perpendicular to one end is $ML^2/3$

a. 17 rad/s²
b. $\boxed{\text{12 rad/s}^2}$ ✓ 11.8 rad/s²
c. 5.4 rad/s²
d. 5.9 rad/s²
e. 8.4 rad/s²



CW $\vec\tau_{F_1} = 0.4(.2 * 9.8)\sin(90)$

CW $\vec\tau_{F_2} = 1(.2 * 9.8)\sin(90)$

$\sum \vec\tau = I\alpha$

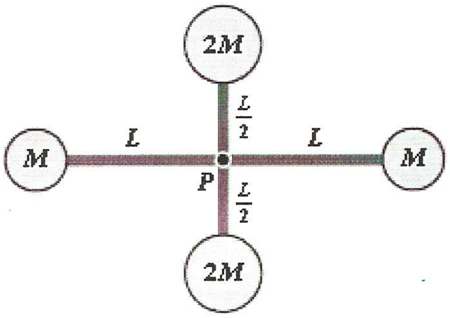
$\dfrac{0.4(.2*9.8) + 1(.2*9.8)}{I} = \alpha$

OVER

I ← the "tricky" part! $I = M_1 r_1^2 + M_2 r_2^2 = 0.232$

$.2(.4)^2 + .2(1)^2$

____ 15. The rigid object shown is rotated about an axis perpendicular to the paper and through point P. The total kinetic energy of the object as it rotates is equal to 1.4 J. If $M = 1.3$ kg and $L = 0.50$ m, what is the angular velocity of the object? Neglect the mass of the connecting rods and treat the masses as particles.



$$KE_{rot} = \frac{1}{2} I \omega^2$$

$$I = \sum m_i r_i^2 = mL^2 + 2m\left(\frac{L}{2}\right)^2 + mL^2 + 2m\left(\frac{L}{2}\right)^2$$

$$I = 3mL^2$$

$$\therefore \omega = \sqrt{\frac{2 * KE_{rot}}{I}} = 1.69 \text{ rad/sec}$$

a. 1.2 rad/s
b. 1.3 rad/s
c. 1.7 rad/s ✓
d. 1.5 rad/s
e. 2.1 rad/s

____ 16. A hydraulic lift raises a 2 000-kg automobile when a 500-N force is applied to the smaller piston. If the smaller piston has an area of 10 cm², what is the cross-sectional area of the larger piston?

a. 40 cm²
b. 80 cm²
c. 160 cm²
d. 392 cm² ✓
e. 196 cm²

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$\frac{500 \text{ N}}{10 \text{ cm}^2} = \frac{2000 * 9.8 \text{ N}}{A_2}$$

$$\therefore A_2 = 392 \text{ cm}^2$$