Exam 1

Name KEY
17 Questions

Select the one response that best answers each question.

1) How long does it take for a rotating object to speed up from 15.0 rad/s to 33.3 rad/s if it has an angular acceleration of 3.45 rad/s^2?

A) 10.6 s B) 4.35 s C) 5.30 s D) 9.57 s E) 63.1 s

2) A pulley has an initial angular speed of 12.5 rad/s and a constant angular acceleration of 3.41 rad/s^2. Through what angle does the pulley turn in 5.26 s? Note: Take the angle to be zero at t=0.

A) 113 rad B) 22.6 rad C) 160 rad D) 42.6 rad E) 19.3 rad

3) In an effort to loosen the bolt on the wheel of a car, a man with a mass of 70 kg steps on the end of a 50–cm tire iron which is extending horizontally from the bolt. How much torque is he applying to the bolt?

A) 340 N m B) 35 N m C) 140 N m D) 70 N m E) 14 N m

4) A man is holding an 8.00–kg vacuum cleaner at arm's length, a distance of 0.550 m from his shoulder. What is the torque on the shoulder joint if the arm is held at 30.0° below the horizontal?

A) 2.20 Nm B) 37.3 Nm C) 21.6 Nm D) 12.6 Nm E) 4.40 Nm

5) A person pushes on a doorknob with a force of 5.00 N perpendicular to the surface of the door. The doorknob is located 0.800 m from axis of the hinges of the door. The door begins to rotate with an angular acceleration of 2.00 rad/s^2. What is the moment of inertia of the door about the hinges?

A) 6.40 kg•m^2 B) 12.5 kg•m^2 C) 8.00 kg•m^2 D) 2.00 kg•m^2 E) 1.00 kg•m^2

6) The arm of a construction crane is 20 m long and makes an angle of +20° with the horizontal. A bucket of cement with a mass of 3000 kg is suspended from the upper end of the crane arm. What is the torque, due to the bucket of cement, acting on the joint where the crane arm attaches to the rest of the crane?

A) ~~4.5×10^5~~ N m
B) 2.0×10^5 N m
C) ~~3.5×10^5~~ N m
D) 2.0×10^4 N m
E) 5.5×10^5 N m

7) What is the absolute pressure at a distance 5.00 m below the surface of a lake? Assume the density of the water in the lake is 1000 kg/m^3 and that atmospheric pressure is 1.01×10^5 Pa. (1 Pa = 1 N/m^2)

A) 4.66×10^5 N/m^2
B) 1.05×10^5 N/m^2
C) ~~5.00×10^3 N/m^2~~
D) 1.50×10^5 N/m^2
E) ~~0.49×10^5~~ N/m^2

8) A board that is 20.0 cm wide, 5.00 cm thick, and 3.00 m long has a density 300 kg/m^3. The board is floating partially submerged in water. What fraction of the volume of the board is below the surface of the water? ρ_{water} = 1000 kg/m^3

A) It depends on which edge of the board is vertical.
B) 0.700
C) 0.200
D) 0.300
E) zero

9) A board is 20.0 cm wide, 5.00 cm thick, and 3.00 m long has a mass of 12.0 kg. The board is floating partially submerged in water. What minimum mass would need to be set on the board to submerge the board? Note that the board is submerged, but the mass resting on top of the board is not. ρ_{water} = 1000 kg/m^3

A) 18.0 kg B) 48.0 kg C) 42.0 kg D) 12.0 kg E) 30.0 kg

10) A person who weighs 550 N empties her lungs as much as possible and is then completely immersed in water while suspended from a cable. In this configuration, the tension in the cable is 21.2 N. What is her density? Hold onto at least six digits throughout the calculation to avoid rounding difficulties. ρ_{water} = 1000 kg/m^3

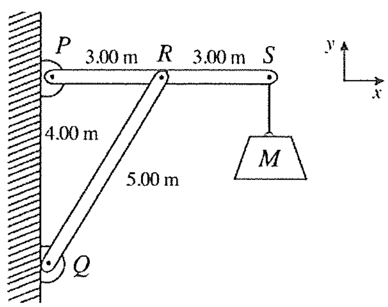
A) 1030 kg/m^3 B) 960 kg/m^3 C) 1050 kg/m^3 D) 56.1 kg/m^3 E) 1040 kg/m^3

11) An incompressible fluid flows steadily through a pipe that has a change in diameter. The fluid speed at a location where the pipe diameter is 8.0 cm is 1.28 m/s. What is the fluid speed at a location where the diameter has narrowed to 4.0 cm?

A) 1.28 m/s B) 0.64 m/s C) 5.12 m/s D) 0.32 m/s E) 2.56 m/s

12) A uniform 300-kg beam, 6.00 m long, is freely pivoted at P, as shown in the figure. The beam is supported in a horizontal position by a light strut, 5.00 m long, which is freely pivoted at Q and is loosely pinned to the beam at R. A load of mass is suspended from the end of the beam at S. A maximum compression of 23,000 N in the strut is permitted, due to safety. Under maximum load, find the magnitude of the x component of the force exerted on the beam by the pivot at P.

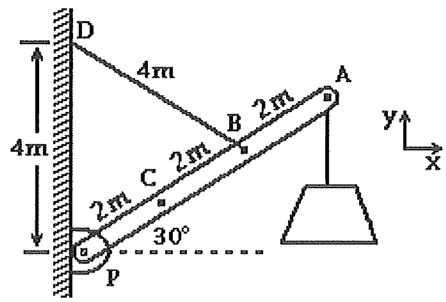
HINTS: You want to apply Newton's Law to the horizontal beam. The force arising from the 'touch' of the P-Q strut has a magnitude of 23,000 N. You don't have to grind through the entire process because you are only being asked for one component of one force.



A) 12,800 N B) 16,000 N C) 13,800 N D) 11,200 N E) 14,400 N

13) Calculate the pressure exerted on the ground by a 57 kg person standing on one foot. Assume that the bottom of the person's foot is 13 cm wide and 28 cm long.

A) 1.6×10^3 Pa
B) 1.5×10^4 Pa
C) 3.8×10^4 Pa
D) 3.4×10^4 Pa



14) A 100 kg nonuniform boom, 6.0 m long, is loosely pinned at the pivot at P. A 600 kg block is suspended from the end of the boom at A. The boom forms a 30° angle with the horizontal, and is supported by a cable, 4.0 m long, between points D and B. Point B is 4.0 m from P, and point D is 4.0 m above P. The center of mass of the boom is at point C, which is 2.0 m from P.

You are going to write the rotational form of Newton's 2nd law about an axis perpendicular to the plane of this page passing through one of the points A, B, C, D, or P. For which axis would the sum of the torques yield an equation where the only unknown is the tension in the 4 m cable?

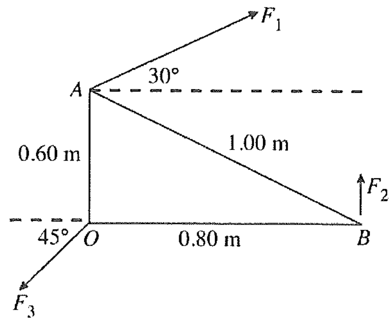
A) A
B) B
C) C
D) D
E) P

15) A solid cylinder and a solid sphere are released from rest at the top of a hill. They have idendical masses and radii. They roll down the hill without slipping. Which will have the least translational kinetic energy when it reaches the bottom of the hill?

A) the sphere
B) they will have the same translational kinetic energy
C) the cylinder
D) it depends on which one was released first.

16) A light triangular plate OAB is in a horizontal plane. Three forces, $F_1 = 6.0$ N, $F_2 = 9.0$ N, and $F_3 = 7.0$ N, act on the plate, which is pivoted about a vertical axes through point O. In the figure, $\vec{F}_2$ is perpendicular to OB. Consider the counterclockwise sense as positive. The sum of the torques about the vertical axis through point O, acting on the plate due to forces F_1, F_2, and F_3, is closest to ________.

NOTE: Take counterclockwise to be POSITIVE.



A) 4.1 N • m   B) −4.1 N • m   C) −5.4 N • m   D) 5.4 N • m   E) zero

17) A turbine blade rotates with angular acceleration $\alpha(t) = 7t^2$ rad/s^2. If at time t = 0 it had a speed of 150 rad/s, through what angle has it turned when t = 15 seconds? Take $\Theta = 0$ at time t = 0. Keep all your calculations at 5 digits or better as you solve this problem.

A) 1,575 rad   B) 31,781 rad   C) 29,531 rad   D) 7,875 rad   E) 8,025 rad

KEY

1.) $\left[\begin{array}{l} \theta(t) = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2 \\ \omega(t) = \omega_0 + \alpha t \end{array}\right] \Rightarrow \left[\begin{array}{ll} \theta(t) = 15t + 1.725\,t^2 & \boxed{1} \\ \omega(t) = 15 + 3.45t & \boxed{2} \end{array}\right]$

@ $t = t_1$, $\omega_1 = 33.3$

$\boxed{2} \Rightarrow 33.3 = 15 + 3.45\,t_1$

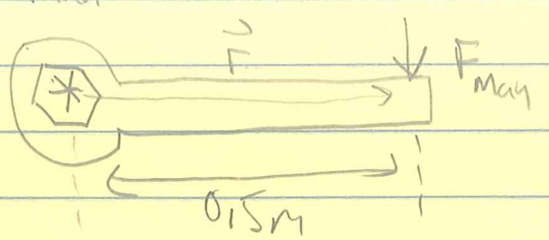
$\therefore t_1 = \underline{5.3 \text{ seconds}}$

2.) $\theta(t) = 12.5t + 1.705t^2 \quad \boxed{1}$

@ $t = 5.26$

$\boxed{1} \Rightarrow \theta(t) = \underline{112.9 \text{ radians}}$

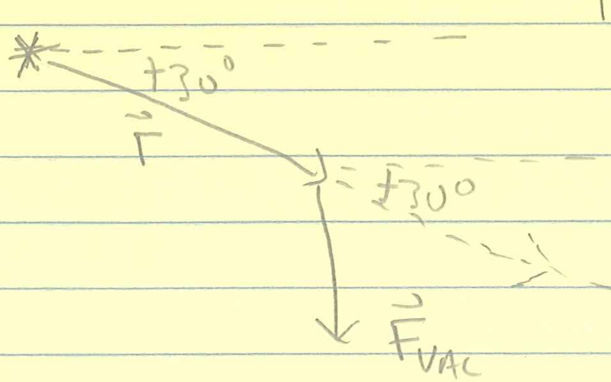
3.) $F_{Man} = 70 * 9.8 = 686 \text{ N}$



$|\vec{\tau}| = |\vec{r}||\vec{F}|\sin(90)$

$= \underline{343 \text{ Nm}}$

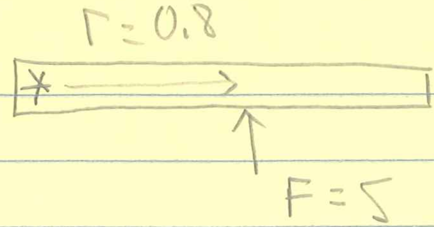
4.) $F_{VAC} = 8 * 9.8 = 78.4 \text{ N}$



$|\vec{\tau}| = 0.55(78.4)\sin(60)$

$= \underline{37.3 \text{ Nm}}$

5.)



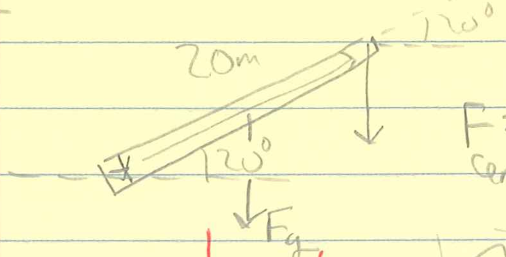
$|\vec{\tau}| = 0.8(5)\sin(90) = 4\ Nm.$

2^{nd} $\quad \sum \tau = I\alpha$

$4 = I(2)$

$2 = I$

6.)



NOT GIVEN
NOT ASKED FOR

$F_{cement} = 3000\,kg * 9.8 = 29400\ NM$

$|\vec{\tau}_{F_{cement}}| = 20(29400)\sin(20)$

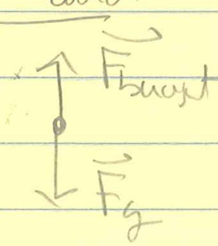
$= 2.01 * 10^5\ Nm$

7.) $P = P_0 + \rho g h$

$P = 1.01 * 10^5 + 1000(9.8)(5) = 1.5 * 10^6\ Pa$

8.) This is the iceberg question from class!

for board



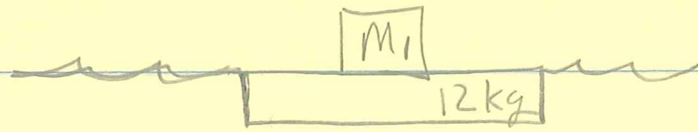
$2^{nd} \Rightarrow F_{buoyant} = F_g$

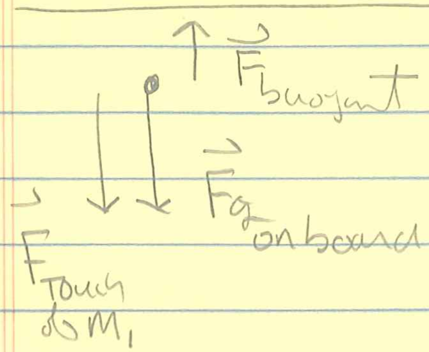
$\rho_{water} V_{\substack{water \\ displaced}}\, g = \rho_{wood} V_{wood}\, g$

Since $V_{\substack{water \\ displaced}} = V_{\substack{board \\ submerged}}$, we have

$$\frac{V_{\substack{board \\ submerged}}}{V_{board}} = \frac{\rho_{wood}}{\rho_{water}} = \frac{300}{1000} = 0.3$$

9.) For the board





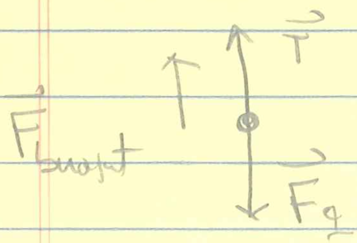
2nd $\sum F = 0$

$F_{touch\ of\ M_1} + F_{g\ on\ board} = F_{buoyant}$

$M_1 g + 12 g = (1000)(0.2 \times 0.05 \times 3)\, g$

$\underline{\underline{M_1 = 18\ \text{Kg}}}$

10.) For person



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

$+21.2 - 550 + \rho_w V g = 0$

$V = 0.053959\ m^3$

This is also the volume of the person.

$M_{person} = \frac{550}{g} = 56.12\ \text{kg}$

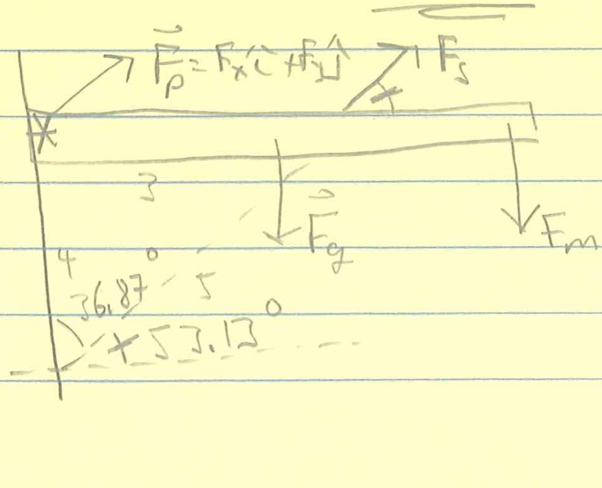
$\therefore \rho_{person} = \frac{56.12}{0.053959} = \underline{1040\ \text{kg}}$

11.) $A_1 V_1 = A_2 V_2$

$\pi (0.04)^2 (1.28) = \pi (0.02)^2 V_2$

$\underline{\underline{V_2 = 5.12\ m/s}}$

12.)



$\vec{F}_s = 23000 \cos(53.13)\,\hat{i} + 23000 \sin(53.13)\,\hat{j}$

You are asked for the x component of $\vec{F}_p$.
ONLY TWO FORCES HAVE x-components

2nd (c) $\sum F_x = 0$

$$F_x + 23000\cos(53.13) = 0$$

$$\therefore F_x = \underline{\underline{-13800 \text{ N}}}$$

I had hoped that
the hints pointed you this way

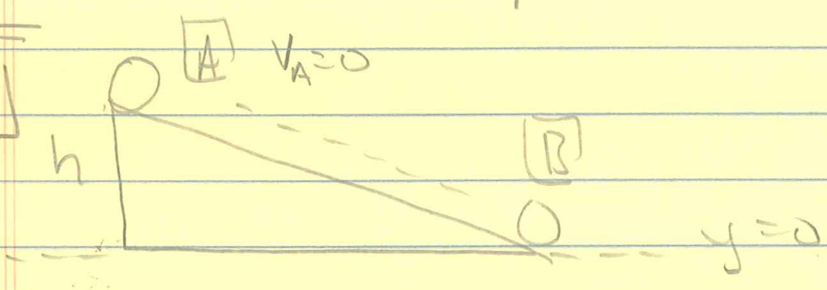
13.) $F = mg = 558.6$ N

$A = 13\text{cm} * 28\text{cm} = 364 \text{ cm}^2 * \frac{1\text{m}}{100\text{cm}} * \frac{1\text{m}}{100\text{cm}} = 0.0364 \text{ m}^2$

$\therefore P = \frac{F}{A} = \underline{15346 \text{ Pa}}$

14.) $\vec{\tau} = \vec{r} \times \vec{F}$ If choose axis so $\vec{r} = 0$, that unknown "disappears". Tcable and $\vec{F}_p$ are the only unknowns!

15.)



$TE_{A} = mgh$

$TE_{B} = \frac{1}{2} m V_B^2 + \frac{1}{2} I \omega_B^2$

Cons. of Energy $\Rightarrow TE_{A} = TE_{B}$ | $V_B = R\omega_B$ $\therefore \omega_B = \frac{V_B}{R}$

$$mgh = \frac{1}{2} m V_B^2 + \frac{1}{2} I \omega_B^2$$

$$mgh = \frac{V_B^2}{2}\left(m + \frac{I}{R^2}\right)$$

So far, this could be for EITHER the cylinder or sphere. Both have same M and R.

For sphere, $I = \frac{2MR^2}{5}$

$$\Rightarrow 2mgh = v_B^2\left(m + \frac{2m}{5}\right) = \frac{7mv_B^2}{5}$$

$$v_B = \sqrt{\frac{10}{7}gh}$$

For cylinder, $I = \frac{MR^2}{2}$

$$\Rightarrow 2mgh = v_B^2\left(m + \frac{m}{2}\right) = v_B^2\left(\frac{3m}{2}\right)$$

$$v_B = \sqrt{\frac{4gh}{3}}$$

$\frac{10}{7} > \frac{4}{3}$, so the cylinder's velocity @ B is smaller.

$\therefore$ $KE_{cylinder}$ translational @B is SMALLER

16.) $\vec{\tau}_{\vec{F}_2} = \vec{r}_2 \times \vec{F}_2 = 0.8(9)\sin(90) = 7.2$ $\boxed{\text{Out}}$ $\boxed{\text{CCW}}$ $+$

$\vec{\tau}_{\vec{F}_3} = 0$

$\vec{\tau}_{F_1} = \vec{r}_1 \times \vec{F}_1 = 0.6(6)\sin(60) = 3.12$ $\boxed{\text{IN}}$ $\boxed{\text{CW}}$ $-$

τ^{ny} $\quad \sum \tau = +7.2 - 3.12 = +\underline{4.08 \text{ Nm}}$

17.) $\alpha(t) = 7t^2$

$\omega(t) = \int \alpha(t) = \frac{7t^3}{3} + \text{const.}$

$\omega(t=0) = 150$

$\therefore \text{const.} = 150$

So we have:

$\omega(t) = \frac{7t^3}{3} + 150$

$\theta(t) = \int \omega(t) = \frac{7t^4}{12} + 150t + \text{const.}$

$\theta(t=0) = 0$

$\therefore \text{Constant} = 0$

$\theta(t=15) = 31781 \text{ radians}$