College Physics

Phys 2010

Exam 3

Fall Semester 2008

Notes
- You may use a calculator
- This test is closed book and closed notes.

NAME: Key

Multiple-Choice Questions

1. A torque of 20.0 N·m is applied to a bolt. The bolt rotates through an angle of 180 degrees. The work done in turning the bolt is:

   A. 72.5 J.
   B. 51.9 J.
   C. 62.8 J.
   D. 49.9 J.
   E. 58.4 J.

   $W = \tau \Delta\theta = (20)(180^\circ = \pi \text{ radians})$
   $= 20\pi = 62.8\text{ J}$

2. A 2.00 kg solid sphere ($I = 2/5\ MR^2$) with a diameter of 50.0 cm is rotating at an angular velocity of 5.0 rad/s. The angular momentum of the rotating sphere is:

   A. 0.55 kg·m²/s.
   B. 0.48 kg·m²/s.
   C. 0.37 kg·m²/s.
   D. 0.25 kg·m²/s.
   E. 0.20 kg·m²/s.

   $L = I\omega \qquad I = 2/5\, mr^2 = (2/5)(2)(0.25)^2 = 0.05\ \text{kg·m}^2$
   $L = (0.05)(5) = 0.25\ \text{kg·m}^2/\text{s}$

3. An ice dancer with her arms stretched out starts into a spin with an angular velocity of 1.00 rad/s. Her moment of inertia with her arms stretched out is 2.48 kg·m². What is her angular velocity when she pulls in her arms to make her moment of inertia 1.40 kg·m²?

   A. 2.67 rad/s
   B. 2.45 rad/s
   C. 2.03 rad/s
   D. 1.90 rad/s
   E. 1.77 rad/s

   $\omega_i = 1\text{ rad/s}, \quad I_i = 2.48\text{ kg·m}^2$
   $\omega_f = ?, \quad I_f = 1.4\text{ kg·m}^2$
   $L_i = L_f \Rightarrow I_i\omega_i = I_f\omega_f \Rightarrow$
   $\omega_f = \frac{2.48}{1.4}(1) = 1.77\text{ rad/s}$

4. Atmospheric pressure is $1.013 \times 10^5\ \text{N/m}^2$. The pressure of the atmosphere in kPa is:

   A. 101.3.
   B. 98.10.
   C. 75.40.
   D. 66.70.
   E. 55.20.

   $P = 1.013\times10^5\ \text{N/m}^2 = 1.013\times10^5\ \text{Pa}$
   $= 1.013\times10^2\ \text{kPa}$
   $= 101.3\ \text{kPa}$

5. Water has a density of 1000 kg/m^3. The column of water that would produce a pressure of 1.0135×10^5 N/m^2 is:

A. 7.3300 m.
B. 9.8200 m.
(C.) 10.340 m.
D. 15.720 m.
E. 20.010 in.

$$P_{liquid} = \rho g d$$

$$1.0135 \times 10^5 = (1000)(9.8)(d) \Rightarrow$$

$$d = 10.34 \text{ m}$$

6. A sphere with a diameter of 10.0 cm is completely submerged in water. The buoyant force of the water on the sphere is:

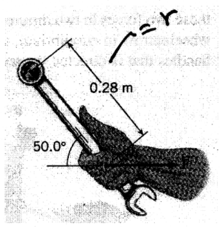
A. 4.25 N.
B. 4.75 N.
(C.) 5.13 N.
D. 5.75 N.
E. 6.00 N.

$$F_B = (mg)_{displaced} = \rho_{water} V_{sphere}\, g$$

$$(1000)\left(\tfrac{4}{3}\pi \times \left(\tfrac{0.1}{2}\right)^3\right)(9.8)$$

$$= 5.13 \text{ N}$$

1. You are installing a spark plug and the manual specifies that it must be tightened with a torque of 45 N.m. Using the data in the drawing, determine the magnitude of force F that you exert on the wrench.

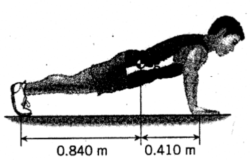


$\tau = rF\sin\theta$

$\tau = (0.28)(F)(\sin 50^\circ) = 45$

$\Rightarrow F = \dfrac{45}{(0.28)(\sin 50^\circ)} = \boxed{210\ N}$

2. The drawing shows a person of mass 60 kg doing push-ups. Find the normal force exerted by the floor on *each* hand and *each* foot, assuming that the person holds this position.



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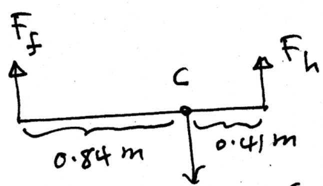


$mg = (60)(9.8) = 588\ N$

$\sum F = F_f + F_h - mg = 0 \Rightarrow$

$F_f + F_h = 588 \quad (1)$

$\sum \tau = F_f(0.84) - F_h(0.41) = 0 \quad$ (choosing c as Pivot)

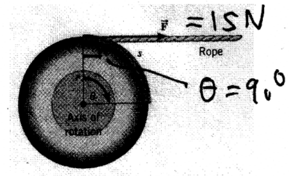
$\Rightarrow 0.84 F_f = 0.41 F_h \quad (2)$

from (1) and (2) $\Rightarrow F_f = 192.8\ N$ and $F_h = 395.2\ N$

For each hand and foot: $F_{hand} = \dfrac{395.2}{2} = \boxed{197.6\ N}$ $\quad \boxed{F_{foot} = 96.4\ N}$

3. The disk shown in the figure is set to spin using the torque applied by the rope. The disk can be considered as a uniform solid disk of radius 25 cm and mass of 1.2 kg (rotational inertia $=\frac{1}{2}MR^2$). The force F = 15 N is applied to the rope for a duration of 3 seconds.

a) Calculate the torque applied to the disk by the rope.



$\tau = rF\sin\theta$

$= (0.25)(15)\sin 90^0$

$= 3.75 \text{ N}\cdot\text{m}$

b) Calculate the angular acceleration of the disk.

$\tau = I\alpha$ We need I : $I = \frac{1}{2}mr^2$

$I = (\frac{1}{2})(1.2)(0.25)^2$

$I = 0.0375 \text{ kg}\cdot\text{m}^2$

$\alpha = \frac{\tau}{I} = \frac{3.75}{0.0375} \Rightarrow$ $\boxed{\alpha = 100 \text{ rad/s}^2}$

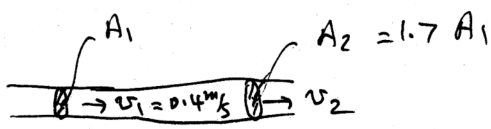
c) If the disk starts at rest, what is its angular speed after 3 seconds?

$\omega_i = 0$ $\omega_f = ?$ $\alpha = 100 \text{ rad/s}^2$, $\Delta t = 3 \text{ s}$

$\omega_f = \omega_i + \alpha\Delta t$

$\omega_f = 0 + (100)(3) = \boxed{300 \text{ rad/s}}$

4. An aneurysm is an abnormal enlargement of a blood vessel such as the aorta. Because of aneurysm, the cross-sectional area A_1 of the aorta increases to $A_2 = 1.7\ A_1$. The speed of blood ($\rho = 1060\ \ kg/m^3$) through a normal portion of the aorta is $v_1 = 0.4\ \ m/s$. Assuming that the aorta is horizontal (the person is lying down), determine (a) the speed of the flow through enlarged cross section, and (b) the amount by which the pressure P_2 in the enlarged region exceeds the pressure P_1 in the normal region.



a) use flow rate : $A_1 v_1 = A_2 v_2$

$$\Rightarrow v_2 = \frac{A_1 v_1}{A_2} = \frac{A_1}{1.7 A_1}(0.4\ m/s)$$

$$\boxed{v_2 = 0.23\ m/s}$$

b) use Bernoulli's equation:

$$P_1 + \tfrac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \tfrac{1}{2}\rho v_2^2 + \rho g y_2$$

but $y_1 = y_2$

$$\Rightarrow P_2 - P_1 = \tfrac{1}{2}\rho v_1^2 - \tfrac{1}{2}\rho v_2^2$$

$$= \tfrac{1}{2}\rho(v_1^2 - v_2^2) = \tfrac{1}{2}(1060)(0.4^2 - 0.23^2)$$

$$\boxed{P_2 - P_1 = 55.5\ Pa}$$

5. A 13.2-kg solid ball of density 3540 kg/m^3 is suspended by a rope from a spring scale. The ball is then lowered into seawater of density 1013 kg/m^3 until it is completely submerged. If the scale is calibrated in units of newtons, what is the reading of the scale?

We need to calculate buoyant force = F_B

$$F_B = (mg)_{\text{displaced water}} = \rho_{\text{water}} V_{\text{displaced}}\, g$$

$$V_{\text{displaced}} = V_{\text{ball}}$$

Thus $$V_{ball} = \frac{m_{ball}}{\rho_{ball}} = \frac{13.2 \text{ kg}}{3540} = 3.7 \times 10^{-3}\ m^3$$

$$\Rightarrow F_B = (1013\ kg/m^3)(3.7 \times 10^{-3})(9.8) = \boxed{37.0\ N}$$

Weight in air $= mg = (13.2)(9.8) = 129.4$ N

$$\Rightarrow \text{Weight in water} = 129.4 - 37 = \boxed{92.4\ N}$$

↓ Same as Scale reading