Exam 3 PHY231 Spring 2013 Section 2 **Form D**

1. A car travels at a constant speed around a flat circular track with a radius of 50.0 m and takes 1.00 minute to complete one revolution. What is the centripetal acceleration of the car?

A) 6.28 m/s^2
B) 5.34 m/s^2
C) 0.652 m/s^2
D) 0.548 m/s^2
E) 0.732 m/s^2
F) 2.21 m/s^2
G) 6.91 m/s^2
H) 0.220 m/s^2

$$a_c = v^2/r \quad T = 2\pi r / v \Rightarrow v = 2\pi r / T$$
$$= (2\pi / T)^2 r = (2\pi/60\,\text{s})^2(50.0\,\text{m}) = 0.548\,\text{m/s}^2$$

2. The mass and radius of the moon are 7.4×10^{22} kg and 1.7×10^6 m, respectively. What is the mass of an object with a weight of 1.71 N on the surface of the moon? ($G = 6.67\times10^{-11}$ Nm^2/kg^2)

A) 0.67 kg
B) 3.73 kg
C) 8.81 kg
D) 4.35 kg
E) 1.00 kg
F) 1.17 kg
G) 2.97 kg
H) 5.82 kg

$$W = mg_{\text{moon}} \quad g_{\text{moon}} = GM_{\text{moon}}/R^2_{\text{moon}}$$
$$m = W/g_{\text{moon}} = \frac{(1.71\,\text{N})(1.70\times10^6\,\text{m})^2}{(6.67\times10^{-11}\,\text{Nm}^2/\text{kg}^2)(7.40\times10^{22}\text{kg})} = 1.00\,\text{kg}$$

3. A spaceship is in orbit around the earth at an altitude of 19,290 km. Which one of the following statements best explains why an astronaut experiences "weightlessness"?

A) The spaceship is in free fall so its floor cannot press upward on the astronaut.
B) The pull of the earth on the spaceship is canceled by the pull of the other planets.
C) The location of the spaceship is equidistant between the earth and the moon.
D) The force decreases as the inverse square of the distance from the earth's center.
E) The force of the earth on the spaceship and the force of the spaceship on the earth cancel because they are equal in magnitude but opposite in direction.
F) The centripetal force of the earth on the astronaut in orbit is zero.
G) The earth's gravitation force is balanced by the centrifugal force on the astronaut.
H) Since the spaceship is above the atmosphere, no air presses down on the astronaut.

4. An airplane engine starts from rest; and 2 seconds later, it is rotating with an angular speed of 420 rev/min. If the angular acceleration is constant, how many revolutions does the propeller undergo during this time?

A) 24
B) 14
C) 7
D) 49
E) 150
F) 17
G) 21
H) 1200

$$\theta = \tfrac{1}{2}(\omega + \omega_0)t = \tfrac{1}{2}(420\,\text{rev/min})(\tfrac{1}{30}\,\text{min}) = 7.0$$

5. A hollow sphere of radius 0.25 m is rotating at 13 rad/s about an axis that passes through its center. The mass of the sphere is 3.8 kg. Assuming a constant net torque is applied to the sphere, how much work is required to bring the sphere to a stop? Note: moment of inertia of a hollow sphere, $I_S = \frac{2}{3}MR^2$.

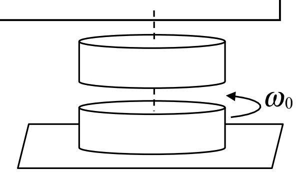
A) 1.02 J
B) 3.83 J
C) 2.72 J
D) 25.5 J
E) 16.3 J
F) 19.9 J
G) 13.4 J
H) 8.54 J

$$W = \Delta K = \tfrac{1}{2}I\omega^2 = \tfrac{1}{3}MR^2\omega^2$$
$$= \tfrac{1}{3}(3.8\,\text{kg})(0.25\,\text{m})^2(13.0\,\text{rad/s})^2 = 13.4\ \text{J}$$

6. A string is wrapped around a pulley of radius 0.20 m and moment of inertia 0.40 kg · m^2. The string is pulled generating an angular acceleration of 14.0 rad/s^2. With what magnitude of force was the string pulled?

A) 14.0 N
B) 17.0 N
C) 19.0 N
D) 35.0 N
E) 22.0 N
F) 28.0 N
G) 21.0 N
H) 33.0 N

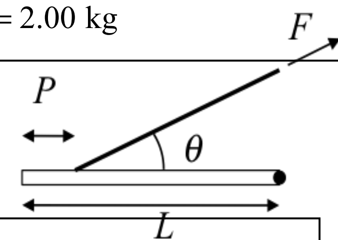
$$\tau = I\alpha \quad \tau = FR$$
$$F = I\alpha / R = (0.40\,\text{kg}\cdot\text{m}^2)(14\,\text{rad/s})/(0.20\text{m})$$
$$= 28.0\,\text{N}$$



7. A solid disk with a mass of 0.50 kg is rotating on a frictionless surface with an angular speed of 15.0 rad/s. Another disk just above the first with the same radius is dropped onto the lower disk. Kinetic friction between the disks brings both disks to a common angular speed of 3.00 rad/s. What is the mass of the top disk?

A) 0.50 kg
B) 1.00 kg
C) 1.50 kg
D) 5.00 kg
E) 2.50 kg
F) 3.00 kg
G) 4.00 kg
H) 2.00 kg

$$L_0 = L, \quad I_0\omega_0 = I\omega = \left(I_0 + I_{\text{top}}\right)\omega$$
$$I_{\text{top}} = I_0\left(\omega_0 - \omega\right)/\,\omega = I_0(15-3)/3 = 4I_0$$
$$M_{\text{top}} = 4M_0 = 2.00\text{ kg}$$



8. A board in equilibrium has a mass of 23.0 kg, length 25.0 m is pivoted about one end. A rope tied a distance of 5.00 m from the other end makes an angle of 15° with the board. What is the magnitude of the force *F*?

A) 545 N
B) 495 N
C) 445 N
D) 395 N
E) 962 N
F) 743 N
G) 689 N
H) 595 N

$$\Sigma\vec{\tau}_i = 0 \quad \vec{\tau}_1 = -(L-P)F\sin\theta; \quad \vec{\tau}_2 = (L/2)mg$$
$$F = \frac{(L/2)mg}{(L-P)\sin\theta} = \frac{(12.5\text{m})(23.0\text{kg})(9.81\text{N/kg})}{(20\text{m}\cdot\sin 15°)} = 545\text{N}$$

9. The maximum compression stress that a bone can withstand is 1.60×10^8 N/m^2 before it breaks. A thighbone (femur), which is the largest and longest bone in the human body, has a cross sectional area of 7.70×10^{-4} m^2. What is the maximum compression force that can be applied to the thighbone?

A) 2.10×10^{11} N
B) 1.20×10^{6} N
C) 4.80×10^{12} N
D) 3.00×10^{3} N
E) 5.40×10^{7} N
F) 1.23×10^{5} N
G) 8.70×10^{5} N
H) 4.23×10^{9} N

$$\frac{F}{A} < 1.6\times10^8\,\text{N/m}^2$$
$$F < (1.6\times10^8\,\text{N/m}^2)(7.70\times10^{-4}\,\text{m}^2) = 1.23\times10^5\,\text{N}$$

10. A force of 250 N is applied to a hydraulic jack piston that is 0.02 m in diameter. If the piston that supports the load has a diameter of 0.15 m, approximately how much mass can be lifted by the jack? Ignore any difference in height between the pistons.

A) 1400 kg
B) 700 kg
C) 250 kg
D) 2800 kg
E) 5600 kg
F) 3300 kg
G) 990 kg
H) 1700 kg

$$P_1 = P_2, \quad F_1/A_1 = F_2/A_2, \quad F_2 = \left(\frac{A_2}{A_1}\right)F_1 = \left(\frac{d_2}{d_1}\right)^2 F_1$$
$$m = \frac{F_2}{g} = \left(\frac{d_2}{d_1}\right)^2 \frac{F_1}{g} = \left(\frac{0.15}{0.02}\right)^2 \frac{250\,\text{N}}{9.81\,\text{N/kg}} = 1400\,\text{kg}$$

11. A balloon inflated with a gas (density = 0.5 kg/m^3) has a volume of 6.00×10^{-3} m^3. If the buoyant force (F_B) exerted on the balloon is 0.0765 N, what is the density of the air?

A) 1.10 kg/m^3 E) 0.13 kg/m^3
B) 1.60 kg/m^3 F) 2.10 kg/m^3
C) 0.09 kg/m^3 G) 1.50 kg/m^3
D) 1.30 kg/m^3 H) 0.11 kg/m^3

$$F_B = \rho_f V g$$
$$\rho_f = F_B / Vg = (0.0765\text{N})/(6\times10^{-3}\text{m}^3 \cdot 9.81\text{N/kg}) = 1.30\text{ kg/m}^3$$

12. You want to fill a 0.0189-m^3 bucket with water to wash your car. Water exits a hose with a speed of 0.61 m/s. The radius of the faucet is 0.0078 m. How long does it take to fill the bucket completely?

A) 9.30 s E) 162 s
B) 17.0 s F) 199 s
C) 28.4 s G) 57.9 s
D) 49.3 s H) 21.3 s

$$V = Avt = \pi r^2 vt$$
$$t = V / \pi r^2 v = 0.0189\text{m}^3 / \left[\pi(0.0078\text{ m})^2(0.61\text{m/s})\right] = 162\text{ s}$$

13. In level flight of an airplane weighing 1.92×10^4 N, the air speed over the top of each wing is 62.0 m/s and the air speed beneath each wing is 54.0 m/s. If the density of the air at this altitude is 1.29 kg/m^3, what is the surface area of *each* wing of the airplane?

A) 16.0 m^2 E) 34.3 m^2
B) 13.3 m^2 F) 25.4 m^2
C) 21.7 m^2 G) 29.0 m^2
D) 5.37 m^2 H) 19.2 m^2

$$P_2 - P_1 = \tfrac{1}{2}\rho\left(v_1^2 - v_2^2\right) = F / A_{\text{two-wings}}$$
$$\tfrac{1}{2}A_{\text{two-wings}} = A_{\text{wing}} = \frac{F}{\rho\left(v_1^2 - v_2^2\right)} = \frac{1.92\times10^4\text{ N}}{1.29)(62^2 - 54^2)\text{N}} = 16\text{m}^2$$

14. Steel has a Young's modulus 2.00×10^{11} N/m^2 and a coefficient of thermal expansion that is 12.0×10^{-6} (°C)$^{-1}$. A steel beam at 10 °C is constrained to a length of 2.50 m. A pressure of 7.20×10^7 N/m^2 is generated at each end of the beam at what temperature?

A) 50.0 °C E) 35.0 °C
B) 20.0 °C F) 25.0 °C
C) 40.0 °C G) 45.0 °C
D) 30.0 °C H) 15.0 °C

$$P = \frac{F}{A} = Y\frac{\Delta L}{L} = Y\frac{\alpha L \Delta T}{L}$$
$$\Delta T = \frac{P}{Y\alpha} = \frac{7.20\times10^7\text{ N/m}^2}{(2.00\times10^{11}\text{ N/m}^2)(12.0\times10^{-6}\text{°C}^{-1})} = 30\text{°C}, \quad T = 40\text{°C}$$

15. How many molecules are in 0.088 kg of carbon dioxide, CO_2? (atomic masses: C = 12 u; O = 16 u. (Avogadro's number is 6.02×10^{23} /mol)

A) 1.20×10^{24} E) 6.02×10^{24}
B) 3.01×10^{24} F) 4.81×10^{24}
C) 2.79×10^{24} G) 5.41×10^{23}
D) 1.83×10^{23} H) 6.02×10^{26}

$$N = N_A n = N_A m(\text{in g}) / m(\text{in u}) \quad \text{u = atomic mass unit}$$
$$= (6.02\times10^{23})(88)/(44\text{u})$$
$$= 1.20\times10^{24}$$

16. Helium atoms at 450 K have an RMS speed of 1675 m/s. What is the speed of the helium atoms if the temperature is raised to 900 K?

A) 1920 m/s E) 2970 m/s
B) 3350 m/s F) 2370 m/s
C) 3770 m/s G) 4280 m/s
D) 3550 m/s H) 3940 m/s

$$\tfrac{1}{2}m\overline{v_1^2} = \tfrac{3}{2}k_B T_1 \quad \tfrac{1}{2}m\overline{v_2^2} = \tfrac{3}{2}k_B T_2 \quad v_{RMS} = \sqrt{\overline{v^2}}$$
$$v_{RMS2} = v_{RMS1}\sqrt{T_2 / T_1} = 1675\text{m/s}\sqrt{900/450 = 2370\text{m/s}}$$