Exam 3 PHY231 Spring 2013 Section 1 **Form A**

1. A car traveling at a constant speed around a flat circular track with a radius of 50.0 m experiences a centripetal acceleration of 0.548 m/s^2. The car takes how long to make one complete revolution of the track?

A) 67.5 s
B) 53.4 s
C) 60.0 s
D) 18.1 s
E) 22.3 s
F) 121 s
G) 47.2 s
H) 33.3 s

$$T = 2\pi r / v; \quad v = \sqrt{a_c r}$$
$$= 2\pi r \Big/ \sqrt{a_c r} = 2\pi\sqrt{r / a_c} = 2\pi\sqrt{50\,\text{m}/(0.548\,\text{m/s}^2)} = 60.0\,\text{s}$$

2. The mass and radius of the moon are 7.40×10^{22} kg and 1.70×10^6 m, respectively. What is the weight of a 1.0-kg object on the surface of the moon?
$(G = 6.67\times10^{-11}\ \text{Nm}^2/\text{kg}^2)$

A) 1.71 N
B) 3.73 N
C) 8.81 N
D) 4.35 N
E) 0.67 N
F) 1.17 N
G) 2.97 N
H) 5.82 N

$$W = mg_{\text{moon}} \quad g_{\text{moon}} = GM_{\text{moon}} \Big/ R_{\text{moon}}^2$$
$$= (1\text{kg})(6.67\times10^{-11}\,\text{Nm}^2/\text{kg}^2)(7.40\times10^{22}\text{kg})/(1.70\times10^6\,\text{m})^2$$
$$= 1.71\text{N}$$

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 centripetal force of the earth on the astronaut in orbit is zero newtons.
B) The pull of the earth on the spaceship is canceled by the pull of the other planets.
C) The spaceship is in free fall so its floor cannot press upward on the astronaut.
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 location of the spaceship is equidistant between the earth and the moon
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. A fan rotating with an initial angular velocity of 1000 rev/min is switched off. In 2 seconds, the angular velocity decreases to 200 rev/min. Assuming the angular acceleration is constant, how many revolutions does the blade undergo during this time?

A) 10
B) 20
C) 30
D) 50
E) 100
F) 125
G) 227
H) 1200

$$\theta = \tfrac{1}{2}(\omega + \omega_0)t = (600\,\text{rev/min})(\tfrac{1}{30}\text{min}) = 20.0$$

5. A hollow sphere of radius 0.25 m is rotating about an axis that passes through its center. The mass of the sphere is 3.8 kg. A constant net torque is applied to the sphere and 13.4 J of work is required to bring the sphere to a stop. What was the initial angular speed? Note: moment of inertia of a hollow sphere, $I_S = \frac{2}{3}MR^2$.

A) 11.1 rad/s
B) 22.3 rad/s
C) 5.62 rad/s
D) 42.9 rad/s
E) 8.88 rad/s
F) 19.2 rad/s
G) 30.9 rad/s
H) 13.0 rad/s

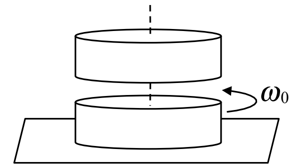
$$W = \Delta K = \tfrac{1}{2}I\omega^2 = \tfrac{1}{3}MR^2\omega^2$$
$$\omega = \sqrt{3W / MR^2} = \sqrt{3(13.4\,\text{J})/(3.8\,\text{kg})(0.25\,\text{m})^2} = 13.0\,\text{rad/s}$$

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 with a force of 28.0 N. What is the magnitude of the resulting angular acceleration of the pulley?

A) 22.0 rad/s^2 E) 11.0 rad/s^2
B) 28.0 rad/s^2 F) 17.0 rad/s^2
C) 56.0 rad/s^2 G) 21.0 rad/s^2
D) 14.0 rad/s^2 H) 33.0 rad/s^2

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

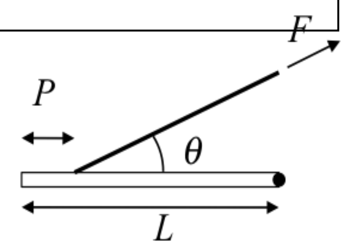
7. A solid disk with a mass of 0.50 kg is rotating on a frictionless surface with an angular speed of 15.0 rad/s. Another disk just above the first with the same radius and a mass of 1.00 kg is dropped onto the lower disk. Kinetic friction between the disks brings both disks to what common angular speed?



A) 2.50 rad/s E) 10.0 rad/s
B) 2.00 rad/s F) 3.50 rad/s
C) 5.00 rad/s G) 4.00 rad/s
D) 7.50 rad/s H) 9.50 rad/s

$$L_0 = L; \quad I_0\omega_0 = (I_0 + 2I_0)\omega$$
$$\omega = I_0\omega_0 / (I_0 + 2I_0) = \omega_0 / 3 = 5\,\text{rad/s}$$

8. A board in equilibrium has length of 25 m is pivoted about one end. A rope tied a distance of 5 m from the other end makes an angle of 15° with the board and is pulled with a force of 540 N. What is the mass of the board?



A) 14.8 kg E) 7.02 kg
B) 19.3 kg F) 9.65 kg
C) 33.3 kg G) 22.8 kg
D) 27.3 kg H) 11.4 kg

$$\vec{\tau}_1 + \vec{\tau}_2 = 0; \quad \vec{\tau}_1 = -(L-P)F\sin\theta; \quad \vec{\tau}_2 = (L/2)mg$$
$$m = \frac{2(L-P)F\sin\theta}{Lg} = \frac{2(20\text{m})(540\text{N})(\sin(15°))}{(25.0\text{m})(9.81\text{N/kg})} = 22.8\text{kg}$$

9. Young's modulus of nylon is 3.70×10^9 N/m^2. A force of 6.00×10^5 N is applied to a 1.50-m length of nylon of cross sectional area 0.250 m^2. By what amount does the nylon stretch?

A) 0.973 mm E) 0.172 mm
B) 0.539 mm F) 0.0539 mm
C) 1.72 mm G) 0.0973 mm
D) 0.0839 mm H) 0.00839 mm

$$\frac{F}{A} = Y\frac{\Delta L}{L} \qquad \Delta L = \frac{FL}{YA} = \frac{(6.00\times10^5\text{ N})(1.5\text{m})}{(3.70\times10^9\text{ Pa})(0.25\text{m}^2)} = 0.973\text{mm}$$

10. A force of 250 N is applied to a hydraulic jack piston that is 0.02 m in diameter. A mass of 1400 kg can be lifted by the jack. Ignoring any difference in height between the pistons, the piston that supports the load has what diameter?

A) 0.071 m E) 0.291 m
B) 0.591 m F) 0.148 m
C) 0.128 m G) 0.222 m
D) 0.369 m H) 0.193 m

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

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 density of air is 1.30 kg/m^3, what is the buoyant force (F_B) exerted on the balloon?

A) 0.0332 N
B) 0.107 N
C) 0.0929 N
D) 0.0643 N
E) 0.0765 N
F) 0.0999 N
G) 0.0442 N
H) 0.0696 N

$$F_B = \rho_f V g = (1.30\,\text{kg/m}^3)(6.00\times10^{-3}\,\text{m}^3)(9.81\,\text{N/kg}) = 7.65\times10^{-2}\,\text{N}$$

12. Water flows through a pipe of diameter 8.0 cm with a speed of 10.0 m/s. It then enters a smaller pipe of diameter 3.0 cm. What is the speed of the water as it flows through the smaller pipe?

A) 29.2 m/s
B) 33.5 m/s
C) 26.7 m/s
D) 71.1 m/s
E) 3.75 m/s
F) 22.3 m/s
G) 1.41 m/s
H) 62.2 m/s

$$v_1 A_1 = v_2 A_2 \quad v_2 = v_1\left(A_1/A_2\right)$$
$$v_2 = v_1\left(d_1^2/d_2^2\right) = (10.0\,\text{m/s})(8.0/3.0)^2 = 71.1\,\text{m/s}$$

13. The surface area of *each* wing of an airplane is 16.0 m^2. In level flight 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 weight of the airplane?

A) 4.92×10^4 N
B) 1.78×10^4 N
C) 3.29×10^4 N
D) 8.47×10^4 N
E) 6.22×10^3 N
F) 9.69×10^3 N
G) 1.53×10^4 N
H) 1.92×10^4 N

$$P_2 - P_1 = \tfrac{1}{2}\rho\left(v_1^2 - v_2^2\right)$$
$$F = A_{2\text{wings}}\tfrac{1}{2}\rho\left(v_1^2 - v_2^2\right)$$
$$= 16\,\text{m}^2(1.29\,\text{kg/m}^3)(62^2 - 54^2)(\text{m}^2/\text{s}^2) = 1.92\times10^4\,\text{N}$$

14. Steel has a Young's modulus 2.00×10^{11} N/m^2 and coefficient of thermal expansion 12.0×10^{-6} (°C)$^{-1}$. A steel beam at 10 °C is constrained to a length of 2.50 m. If the temperature of the beam is increased from 10 °C to 40.0 °C, what pressure is generated at each end of the beam.

A) 5.22×10^7 N/m^2
B) 7.20×10^7 N/m^2
C) 9.33×10^7 N/m^2
D) 3.33×10^6 N/m^2
E) 8.39×10^7 N/m^2
F) 1.44×10^8 N/m^2
G) 1.13×10^6 N/m^2
H) 7.99×10^7 N/m^2

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

15. If there are 1.20×10^{24} molecules in 0.088 kg of a substance, what is its atomic mass?

A) 22.0 u
B) 44.1 u
C) 88.0 u
D) 16.0 u
E) 32.0 u
F) 64.3 u
G) 48.2 u
H) 10.9 u

$$m\ (\text{in u}) = m/n\ (m \text{ in g}) \quad \text{u} = \text{atomic mass unit}$$
$$= m/(N/N_A) = (88)/(1.2\times10^{24})/(6.02\times10^{23}) = 44.1\,\text{u}$$

16. Helium atoms at 450 K have an RMS speed of 1675 m/s. At what temperature does the speed increase to 2372 m/s?

A) 902 K
B) 635 K
C) 544 K
D) 1024 K
E) 732 K
F) 855 K
G) 697 K
H) 499 K

$$\tfrac{1}{2}m\overline{v_1^2} = \tfrac{3}{2}k_B T_1 \quad \tfrac{1}{2}m\overline{v_2^2} = \tfrac{3}{2}k_B T_2 \quad v_{RMS} = \sqrt{\overline{v^2}}$$
$$T_2 = T_1(v_{RMS2}/v_{RMS1})^2 = (450\,\text{K})(2372/1675)^2 = 902\,\text{K}$$