Physics 124 - Analytical Physics
FIRST COMMON HOUR EXAM
Monday, February 25, 2013

Answers

(your name sticker with exam code)

SIGN HERE:

1. The exam will last from 9:40 - 11:00 p.m. Use a #2 pencil to make entries on the answer sheet. Enter the following ID information now, before the exam starts.
2. In the section labeled NAME (Last, First, M.I.) enter your last name, then fill in the empty circle for a blank, then enter your first name, another blank, and finally your middle initial.
3. Under STUDENT # enter your 9-digit RUID Number.
4. Enter 124 under COURSE, and your section number (see label above) under SEC.
5. Under CODE enter the exam code given above.
6. During the exam, you may use pencils, a calculator, and one 8.5 x 11 inch sheet (both sides) with formulas and notes.
7. There are 15 multiple-choice questions on the exam. For each question, mark only one answer on the answer sheet. There is no deduction for an incorrect answer, so even if you cannot work out the answer to a question, you should make an educated guess. **At the end of the exam, hand in the answer sheet and the cover page. Retain this question paper for future reference and study.**
8. When you are asked to open the exam, make sure that your copy contains all 15 questions. Raise your hand if this is not the case, and a proctor will help you. Raise your hand if you have a question.
9. Please SIGN the cover sheet under your name sticker and have your student ID ready to show to the proctor during the exam.

Some possibly helpful numbers: $G = 6.67 \times 10^{-11} \text{ m}^3/(\text{kg s}^2)$, $g = 9.8 \text{ m/s}^2$, $\rho_{\text{water}} = 10^3 \text{ kg/m}^3$, $1 \text{ atm} = 1.01 \times 10^5 \text{ Pa}$, $I_{\text{disk}} = \frac{1}{2}MR^2$
1. Calculate the net torque about point O for the two forces shown in the figure. The rod and both forces are in the plane of the page. Take positive torques to be counterclockwise.

\[ F_2 = 12.0 \text{ N-m} \]
\[ F_1 = 8.00 \text{ N} \]

\[ 2 \times 12.0 \sin 30^\circ = 2 \times 6.0 = 12 \text{ N-m} \]

2. A large-mass wheel rotates with an initial angular velocity of \( \omega_0 \). It is subject to a certain torque \( \tau \) which is slowing the rotation of the wheel. The time for the wheel to stop rotating in this case is \( T \). If instead the braking torque is \( 2\tau \), the time to stop the wheel goes to

a) \( T \) (stays the same) \\
b) \( 2T \) \\
c) \( 4T \) \\
d) \( \frac{T}{2} \) \\
e) \( \frac{T}{4} \)

3. A hoop of mass 50 kg rolls without slipping. The center of mass of the hoop has a translational speed of 4.0 m/s. The total kinetic energy of the hoop is:

a) 200 J \\
b) 400 J \\
c) 1100 J \\
d) 600 J \\
e) None of the other alternatives is correct

\[ K = K_t + K_{rot} \]
\[ = \frac{1}{2} m v^2 + \frac{1}{2} I \omega^2 , \quad I = m R^2 \]
\[ = m v^2 = 800 \text{ J} \]

4. An artist constructs the perfectly-balanced mobile shown. If the artist decides to make the star twice as massive, and not change the length of any crossbar or the location of any object, what does she have to do with the mass of the smiley face to keep the mobile in perfect balance? Note that she may have to change masses of other objects to keep the entire structure balanced.

a) make it eight times more massive \\
b) make it four times more massive \\
c) make it two times more massive \\
d) nothing \\
e) impossible to tell

5. A flexible but non-stretchable rope is wrapped halfway around a fixed disc and both ends of the rope hang vertically down. The axis of the disc lies horizontally and the radius of the disc is 0.15 m. The friction coefficient between the rope and the disc is 0.23. One end of the rope is held by a force of 35 N directed vertically down. The maximum load (in N) that the other end of the rope can hold without the rope sliding is closest to:

a) 72 \\
b) 35 \\
c) 18 \\
d) 152 \\
e) 233

\[ T_{load} = T_0 e^{\mu \theta} \]
\[ = 35 e^{0.23 \times 3.14} \]
\[ = 72 \text{ N} \]
6. A man weighing 800 N stands halfway up a ladder of negligible weight as shown. Assuming that the wall-ladder contact is frictionless, the wall pushes against the ladder with a force of:
   a) 200 N
   b) 89 N
   c) 100 N
   d) 400 N
   e) 0 N

   \[ (\frac{1}{2})mg \times 4 \text{ m} \times \theta = |N_w| \cos \theta \]
   \[ |N_w| = \frac{mg \times \tan \theta}{2} = \frac{800}{2} = 200 \text{ N} \]

7. A wire has a diameter of 0.75 mm. It is stretched 0.2% of its original length when a mass of 5 kg is hung from it. What is the Young’s modulus of the wire?
   a) 1.4 x 10^10 N/m^2
   b) 5.5 x 10^10 N/m^2
   c) 1.7 x 10^11 N/m^2
   d) 5.6 x 10^8 N/m^2
   e) 1 x 10^9 N/m^2

8. Rhea, one of Saturn’s moons, has a radius of 8 x 10^5 m and an acceleration due to gravity of 0.3 m/s^2 at its surface. At what distance above Rhea’s surface is the acceleration due to gravity 0.1 m/s^2?
   a) 0.6 x 10^6 m
   b) 1.6 x 10^6 m
   c) 1.4 x 10^6 m
   d) 0.4 x 10^6 m
   e) 0.8 x 10^6 m

9. Suppose that a planet existed whose mass and radius are one-third of their respective values for the earth. The acceleration of gravity on the surface of this planet is then:
   a) \( g/9 \)
   b) \( g/3 \)
   c) \( g \)
   d) \( 3g \)
   e) \( 9g \)

10. The mean radius of the orbit of the planet Neptune is about 30 times the Earth’s mean orbital radius about the Sun. It follows that the period of one orbit for Neptune is about:
   a) 5.5 years
   b) 10 years
   c) 164 years
   d) 900 years
   e) 960 years

11. Far from the Sun (\( R \approx \infty \)), a spacecraft is out of fuel and its kinetic energy is zero. If only the gravitational force of the Sun were to act on it (neglect other solar system objects) the spacecraft would eventually crash into the Sun. The mass of the Sun is \( 2 \times 10^{30} \) kg and its radius is \( 7 \times 10^8 \) m. Find the speed of the spacecraft when it crashes into the Sun.
   a) 8.0 x 10^3 m/s
   b) 1.2 x 10^4 m/s
   c) 3.4 x 10^4 m/s
   d) 7.8 x 10^4 m/s
   e) 6.2 x 10^5 m/s
12. A submarine dives 30 m deep into a lake \( (\rho_{\text{water}} = 10^3 \text{kg/m}^3) \). Pressure inside the submarine remains at 1 atm. Ignore the support forces from the submarine, and calculate the net force on a submarine window of area 0.5 m\(^2\) from the pressures.

\[
\begin{align*}
\text{a)} & \quad 0.80 \times 10^5 \, \text{N} \quad P_0 = 9.8 \times 10^3 \times 9.81 \times 30 \\
\text{b)} & \quad 1.0 \times 10^5 \, \text{N} \quad P_c = 2.9 \times 10^5 \, \text{Pa} \\
\text{c)} & \quad 1.5 \times 10^5 \, \text{N} \quad P_c = 1.0 \times 10^5 \, \text{Pa} \\
\text{d)} & \quad 2.0 \times 10^5 \, \text{N} \quad \Delta P = (P_o + P_c - P_a)A \\
\text{e)} & \quad 3.0 \times 10^5 \, \text{N} \quad \Delta P = 2.9 \times 10^5 \times 9.81 = 1.45 \times 10^5 \, \text{N}
\end{align*}
\]

13. A fluid flows from a large diameter pipe (Region 1) into a smaller diameter pipe (Region 2) which is at the same height. If \( v_1 \), \( P_1 \) are the velocity and pressure in Region 1 and \( v_2 \), \( P_2 \) are the velocity and pressure in Region 2, which of the following is correct?

\[
\begin{align*}
\text{a)} & \quad v_1 < v_2, \quad P_1 = P_2 \\
\text{b)} & \quad v_1 < v_2, \quad P_1 < P_2 \\
\text{c)} & \quad v_1 > v_2, \quad P_1 < P_2 \\
\text{d)} & \quad v_1 > v_2, \quad P_1 > P_2 \\
\text{e)} & \quad v_1 < v_2, \quad P_1 > P_2 \\
\end{align*}
\]

14. The buoyancy force on a body fully immersed in a fluid depends upon all of the following, EXCEPT:

\[
\begin{align*}
\text{a)} & \quad \text{the density of the body.} \\
\text{b)} & \quad \text{the volume of the body.} \\
\text{c)} & \quad \text{the density of the fluid.} \\
\text{d)} & \quad \text{the volume of the fluid displaced.} \\
\text{e)} & \quad \text{There are no exceptions.}
\end{align*}
\]