PHYSICS-2101 Fall Semester 2012
Examination 3
November 13, 2012

Instructor and section (circle yours)
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LSU ID ___________________________

Name (print) __________________________________________

Signature ____________________________________________

TURN OFF AND PUT AWAY ALL CELL PHONES, PAGERS, iPods, MP3s, OR ANY OTHER
COMMUNICATIONS, AUDIO, OR VIDEO DEVICES

Have your LSU ID ready when you turn in your paper.

You may not use cell phone or smart phone application as your calculator.

You may use an ordinary scientific or even graphing type calculator, as long as it is not of the "full keyboard"

sort.

Examine your paper to be sure it is complete and legible. There should be 3 problems and 3 questions, totaling

100 points. Examine your formula sheet as well. It should include only 3 pages.

For the multiple choice questions, clearly indicate your selected answer(s) for each of the part(s) of the

question, circle the correct answers! For some questions there may be more than one correct response. If so,

be sure mark each one. There is room on the paper for scratch work or calculations, but that work will not be

checked or graded. There is no partial credit awarded for multiple choice questions.

For the problems, show your work in the space provided. Even a correct answer, without supporting work,

will receive little or no credit. Partial credit may be awarded for problems if warranted.

Be sure that numerical answers appear with appropriate SI units. Points will be deducted for missing, incorrect,

or "silly" units.

If the final answer is, in fact, a dimensionless quantity, please write the numerical result followed by the word

"dimensionless."

If you need more room for your problem solution you may write on the back of the page, but be sure to add a

note to look on the back. Otherwise anything on the back of the paper will be regarded as scratch work and will

not be checked or graded.

You will have approximately 60 minutes to complete this examination.

Solutions will be posted to the course web page within a few days.
**Question #1 (10 pts)**

As shown at a particular moment in the figure below, two particles move in $xy$-plane. Particle 1 has mass $m_1 = 2.0$ kg and speed $v_1 = 2.2$ m/s, and it is at distance $d_1 = 1.5$ m from point O. Particle 2 has mass $m_2 = 3.1$ kg and speed $v_2 = 2.6$ m/s, and it is at distance $d_2 = 2.8$ m from point O.

1. (5 pts) What is the magnitude of the net angular momentum of the two particles about O?

(a) 29.0 kg m$^2$/s  
(b) 6.0 kg m$^2$/s  
(c) 16.0 kg m/s  
(d) 4.0 kg m$^2$/s  
(e) 11.0 kg m/s

2. (3 pts) What is the direction of the net angular momentum of the two particles about O?

(a) Positive z-direction  
(b) Negative z-direction  
(c) Positive x-direction  
(d) Negative y-direction  
(e) Negative x-direction

3. (2 pts) In general, what is the condition for a system in which the net angular momentum is conserved?

(a) Net external force is zero  
(b) Net work done by external forces is zero  
(c) Net external torque is zero.  
(d) All external forces are conservative forces.  
(e) Net linear momentum is conserved.
Problem #1 (20 pts): Show your work

A uniform ladder is 10 m long and weighs 200 N as shown schematically in the figure. The ladder leans against a vertical, frictionless wall. A horizontal force \( \vec{F} \) is applied to the ladder at a distance \( d = 2.0 \) m from the base (measured along the ladder).

(a) (10 pts) If \( F = 50 \) N, what are both vertical and horizontal components of the force, acting on the ladder from the ground, in order to keep the ladder in equilibrium.

\[
\begin{align*}
X &= F + \frac{l}{2} = 0 \\
Y &= N - mg = N - W = 0 \\
\text{torque} &= F_w l \sin 45^\circ - W \left( \frac{l}{2} \cos 45^\circ + \frac{d}{2} \sin 45^\circ \right) = 0 \\
\therefore F_w &= \frac{l}{2} W + Fd \\
F_w &= \frac{l}{2} W + \frac{1}{5} F = 100N + 10N = 110N \\
\boxed{F_5 = F_w - F = 110N - 50N = 60N} \\
\begin{align*}
N &= 200N \\
f_s &= 60N
\end{align*}
\]

(b) (10 pts) Suppose the coefficient of static friction between the ladder and the ground is 0.38. What is the minimum value of the force magnitude \( F \) in order to keep the ladder from sliding along the ground?

\[
\begin{align*}
\frac{f_s^{\text{max}}}{N} &= \mu_s \cdot N \\
F_{\text{min}} &= F_w - \frac{f_s^{\text{max}}}{\mu_s} \left( \frac{1}{2} W + \frac{1}{5} F_{\text{min}} \right) - \mu_s W \\
\therefore \frac{4}{5} F_{\text{min}} &= \left( \frac{1}{2} - \mu_s \right) W \\
F_{\text{min}} &= \frac{5}{4} \left( \frac{1}{2} - \mu_s \right) W = 0.15W = 30N
\end{align*}
\]
Question #2 (15 pts)

Consider a small planet (radius $R$ and mass $M$) and a second particle (mass $m$), as shown. The distance between the particle and the center of the planet is $r$. For the questions below, the potential energy of the system is zero for the infinite separation.

(1) (3 pts) If the magnitude of the force on the planet due to the particle is $F$, then the magnitude of the force on the particle due to the planet

(a) is greater than $F$.
(b) is equal to $F$.
(c) is less than $F$.
(d) cannot be determined.

(2) (6 pts) With what kinetic energy will the particle hit the planet if the particle is released from rest at a distance $r = 2R$ from the center of the planet?

(a) $\frac{GmM}{2R}$; (b) $-\frac{GmM}{2R}$; (c) $\frac{GmM}{R}$; (d) $\sqrt{\frac{GM^2}{mR}}$; (e) $\frac{GmM}{R^2}$

(c) (6 pts) What is the orbital speed of the particle if it is uniformly orbiting the planet in a circular orbit of radius $r = 2R$?

(a) $\sqrt{\frac{2GM}{R}}$; (b) $\sqrt{\frac{GM}{R}}$; (c) $\sqrt{\frac{GM}{2R}}$; (d) $\sqrt{\frac{GM^2}{mR}}$; (e) $\sqrt{\frac{GM}{R^2}}$
Problem #2 (20 pts): Show your work

In the figure, a square of edge length 2.0 m is formed by four identical spheres of mass \( m = 100 \text{ kg} \).

(a) (5 pts) The sphere \( M \) of 200 kg is relocated from \( x = \infty \) to the current position at the center of the square. How much is the change of gravitational potential energy due to this relocation?

\[
\Delta U = U - U_\infty = -4G \frac{mm}{\gamma} \quad (r = \sqrt{2} \text{ m})
\]

\[
= -3.77 \times 10^{-6} \text{ J}
\]

(b) (5 pts) In the relocation process, how much work is done by the gravitational force acting on the sphere \( M \).

\[
W = -\Delta U = 3.77 \times 10^{-6} \text{ J}
\]

(c) (5 pts) If the sphere \( M \) is simply released from \( x = \infty \) with a negligible initial push, what is its kinetic energy when it arrives at the center of the square?

\[
KE = W ( = -\Delta U) = 3.77 \times 10^{-6} \text{ J}
\]

(d) (5 pts) What is the net gravitational force acting on the sphere \( M \) at the moment when it is at the center of the square due to the other masses?

zero !
Question #3 (15 pts)
A cubic block, 10.0 cm on a side, floats at water surface with its lower surface 5.0 cm below the surface (see the cross section view in the figure). The density of the water ($\rho_{\text{water}}$) is 1000 kg/m$^3$. The system is under the atmospheric pressure ($P_{\text{atm}} = 1.01 \times 10^5$ Pa).

(1) (5 pts) The gauge pressure at the lower face of the block is

(a) 101490 Pa.
(b) $1.01 \times 10^5$ Pa.
(c) 0.0 Pa.  
(d) 490 Pa.
(e) 980 Pa.

\[ \Delta P = P - P_{\text{atm}} = \rho g h = 10^3 \cdot 9.8 \cdot 0.05 = 490 \text{ Pa} \]

(2) (5 pts) The buoyant force acting on the block is

(a) $4.9 \times 10^6$ N.
(b) $9.8 \times 10^6$ N.
(c) undetermined without knowing the density of mass of the block.
(d) 4.9 N.
(e) 9.8 N.

(3) (5 pts) Now assume you put some oil on the top of the water, and if $\rho_{\text{oil}} < \rho_{\text{water}}$, the block

(a) would not change its position.
(b) would move downward.
(c) would move upward.
(d) cannot be determined without knowing the density of oil.
Problem #3 (20 pts): Show your work

In the figure, two identical springs of spring constant $k = 2.5 \text{ N/cm}$ are attached to a block of mass $m = 0.2 \text{ kg}$. The block is set into motion by displacing the block 3.0 cm to the right of the equilibrium (the positive direction), and letting it go from rest (no friction).

(a) (5 pts) What is the angular frequency $\omega$ of the oscillatory motion?

\[ F = -2kx = ma \]
\[ \alpha = - \frac{2k}{m} x \]
\[ \omega = \sqrt{\frac{2k}{m}} = 50 \text{ (rad/s)} \]
\[ k = 250 \text{ N/m} \]

(b) (5 pts) What is the period $T$ of the oscillatory motion?

\[ T = \frac{1}{f} = \frac{2\pi}{\omega} = 1.26 \text{ s} \]
\[ T = 0.126 \text{ s} \]

(c) (5 pts) What is the maximum speed of the block?

\[ V_m = \omega \cdot x_m = 1.58 \text{ m/s} = 68 \times 10^{-5} \text{ (0.03 x 50)} \]
\[ V_m = 1.5 \text{ m/s} \]

(d) (5 pts) How long it will take to go for the 2nd time through the equilibrium position with the velocity pointing rightward?

\[ \Delta \theta = \frac{3}{4} T = 0.945 \text{ (s)} \]
\[ \Delta \theta = 0.0945 \text{ (s)} \]