Examination 1

Name: ___________________________  
Section: _________________________  

Physics 201  
Fall 2012  
Hans A. Schuessler

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Time: 1 hour 15 minutes

Show all of your work.

Part I: Multiple Choice Questions

1. What are the units of the following quantities? (10pts)

(a.) Force  
(b.) Tension  
(c.) Gravitational Constant  
(d.) Spring Constant  
(e.) Acceleration  
(f.) Mass  
(g.) Static friction  
(h.) Kinetic friction  
(i.) Radial acceleration  
(j.) Velocity

[N], [N], [N/m²], [N/m], [m/s²], [kg], [μs], [μk], [m/s²], [m/s]
2. A spring having a force constant of 15.0 N/cm and an un-stretched length of 20.0 cm is pulled so that it is 23.0 cm long. The force required to stretch it this much is

(a.) 45 N.
(b.) 300 N.
(c.) 322.5 N.
(d.) 345 N.

3. A person pushes horizontally with constant force $P$ on a 250 N box resting on a frictionless horizontal floor. Which of the following statements about this box is correct?

(a.) The box will accelerate no matter how small $P$ is
(b.) The box will not accelerate unless $P > 250$
(c.) The box will move with constant velocity because $P$ is constant
(d.) Once the box is set moving, it will come to a rest after $P$ is removed

4. If you were to move into outer space far away from any stars or planets:

(a.) Your mass would change, but your weight would not change
(b.) Your weight would change, but your mass would not change
(c.) Both your mass and weight would change
(d.) Neither your mass nor your weight would change
5. (a) What is the mass of a book that weighs 3.20 N in the laboratory? (b) In the same lab, what is the weight of a dog whose mass is 14.0 kg?

(a.) \[ mg = W \]
\[ m = \frac{W}{g} = \frac{3.2}{9.81} = 0.326 \text{ kg} \]

(b.) \[ F = 14 \times 9.8 = 137 \text{ N} \]

6. If two tiny identical spheres attract each other with a force of 3.0 nN when they are 25 cm apart, what is the mass of each sphere?

The spheres attract each other with the gravitational force

\[ F_g = G \frac{m_1 m_2}{r^2} \]
\[ m = r \sqrt{\frac{F_g}{G}} \]

\[ G = 6.673 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2} \]

\[ m = 0.25 \sqrt{\frac{3 \times 10^{-9}}{6.673 \times 10^{-11}}} = 1.7 \text{ kg} \]
Part II: Problems

7. (15 pts) A snowball rolls off a barn roof that slopes downward at an angle of 40.0°. The edge of the roof is 28.0 m above the ground, and the snowball has a speed of 7.00 m/s as it rolls off the roof. Ignore air resistance.

How far from the edge of the barn does the snowball strike the ground if it doesn’t strike anything else while falling?

\[ x = \frac{1}{2} a x t^2 = \frac{1}{2} \times 9.8 \times 1.925^2 \]

\[ x = 10.6 \text{ m} \]
8. The 4.00 kg block in the figure is attached to a vertical rod by means of two strings. When the system rotates about the axis of the rod, the strings are extended as shown in the figure and the tension in the upper string is 100.0 N. (a) What is the tension in the lower cord? Start with a free-body diagram of the block (b) What is the speed of the block?

Make a force diagram before you start solving.

The block moves in a circle of

\[ r = \sqrt{1.25^2 - 1.00^2} = 0.75 \text{ m} \]

Each string makes an angle \( \theta \) with the vertical

\[ \cos \theta = \frac{1.00}{1.25} \quad \theta = 36.9^\circ \]

The block has an acceleration \( a_r = \frac{v^2}{r} \)

(a) What is the tension in the lower cord?

\[ \Sigma F_y = m a_y \Rightarrow T_u \cos \theta - T_e \cos \theta - mg = 0 \]

\[ T_e = T_u \cos \theta = 100 - \frac{4 \times 9.8}{\cos 36.9^\circ} = 51 \text{ N} \]

(b) What is the speed of the block

\[ \Sigma T_x = m a_x \Rightarrow (T_u + T_e) \sin \theta = \frac{m v^2}{r} \]

\[ v = \sqrt{r (T_u + T_e) \sin \theta} = \sqrt{0.75 \times 15 \times \sin 36.9^\circ} = \frac{4.26 \text{ m}}{s} \]
Two boxes are connected by a light string that passes over a light, frictionless pulley. One box rests on a frictionless ramp that rises at 30.0° above the horizontal, and the system is released from the rest. (a) Make free-body diagrams of each box. (b) Which way will the 50.0 kg box move, up the plane or down the plane? Or will it even move at all? Show why or why not. (c) Find the acceleration of each box.

\[ \Sigma F_x = 0 \quad \text{applied to } m_1 \quad \text{gives} \quad T - m_1 g \sin \phi = m_1 a \]
\[ \Sigma F_y = m_1 g \quad \text{applied to } m_2 \quad \text{gives} \quad m_2 g - T = m_2 a \]

Compare these two equations by adding. This eliminates \( T \) and gives:

\[ a = \frac{m_2 g - m_1 g \sin \phi}{m_1 + m_2} = \frac{25.4 - 24.5}{30 + 30} = \frac{0.9}{60} \]

The lighter box pulls the heavier one up.

\[ a = \frac{m_2 g}{m_1 + m_2} = \frac{25.4}{30} \quad \text{so} \quad a = \frac{25.4}{30} \]

Therefore, the 30 kg box moves down and the 50 kg box moves up.
10. (a) What is the period of revolution of a satellite with mass \( m \) that orbits the Earth at a height of 6380 km (note \( r_E = 6.38 \times 10^6 \) m)? (b) How far in km is the satellite above the surface of the Earth?

\[
T = 2\pi\sqrt{\frac{r^3}{Gm}}
\]

\[
F = \frac{GMm}{r^2}
\]

\[
T = \frac{2\pi\sqrt{r^3}}{v}
\]

\[
= \frac{2\pi\sqrt{7800 \times 10^3}}{7.11 \times 10^3} = 116 \text{ min}
\]

\[
\frac{7800}{6380} = \frac{380}{1500} = 0.253 \text{ days}
\]

\[
a = \frac{\omega^2r}{2}
\]

\[
\omega = \frac{2\pi}{T} = \frac{2\pi}{116 \text{ min}}
\]

\[
r = \frac{GM}{\omega^2}
\]

\[
r = \frac{6.38 \times 10^6 \times 6.67 \times 10^{-11}}{\left(\frac{2\pi}{116}\right)^2}
\]

\[
r = 7800 + 6380 = 14180 \text{ km}
\]

\[
a = \frac{GM}{r^2}
\]

\[
a = \frac{6.67 \times 10^{-11} \times 6.4 \times 10^{24}}{(14180)^2} = 9.2 \times 10^{-6} \text{ m/s}^2
\]