Examination 1

Name: ____________________________

Section: ____________________________

Physics 201
Fall 2015
Hans Schuessler

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Time: 1 hour 20 minutes

Show all of your work.

Part I: Multiple Choice Questions

1. Based only on consistency of units, which of the following formulas is not correct? In each case, $x$ is distance, $v$ is speed, $t$ is time and $a$ is acceleration. (There may be more than one answer.)

   a.) $v^2 = ax$
   
   b.) $a = \frac{x}{t^2}$
   
   c.) $a^2 = \frac{v^2}{t^2}$
   
   d.) $x = \frac{v}{a}$
   
   e.) $v = \frac{Ft}{m}$

2. Write down the units of:

   a.) static friction $\mu_s$ [none]
   b.) force $F$ [N]
   c.) gravitational constant $G$ \([\frac{Nm^2}{Kg^2}]\)
   d.) spring constant $k$ \([\frac{N}{m}]\)
   e.) radial acceleration $a_r$ \([\frac{m}{s^2}]\)
3. A ball thrown horizontally from the top of a building hits the ground in 0.50 s. If it had been thrown with four times the speed in the same direction, it would have hit the ground in

(a.) 4.0 s.
(b.) 0.5 s.
(c.) 1.5 s.
(d.) more than 3.0 s.

4. A massive object is in an elevator on a spring scale. Which of the following statements must be FALSE? (There may be more than one correct choice.)

The reading of the scale is:

(a.) always greater when the elevator is moving upward.
(b.) zero when the elevator is in free fall.
(c.) smaller when the elevator is moving downward at a constant speed than when the elevator is at rest.
(d.) greater when the elevator is moving upward with constant acceleration than when the elevator is at rest.

5. How long would it take a car starting from rest and accelerating a 8 m/s² to reach a distance of 100m?

(a.) 12.5s
(b.) 3.5s
(c.) 10s
(d.) 5s

\[ \frac{v^2}{2a} = x, \quad t = \sqrt{\frac{2x}{a}} \]
6. 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.) 90 N.
(c.) 650 N.
(d.) 345 N.

\[ F = k \Delta x = \frac{15 \, N}{cm} \cdot 3 \, cm = 45 \, N \]

**Part II: Problems**

7. Forces \( F_A \) and \( F_B \) are the only forces that act on an object that has a mass of 5kg. \( F_A \) has its direction to the east and a magnitude of 3N. \( F_B \) is directed to the north and has a magnitude of 4N.

(a.) Make a sketch of the problem
(b.) What is the magnitude of the total force?
(c.) What is the magnitude of the objects acceleration?
(d.) What is the direction of the acceleration due north (find the angle)?

\[ F = \sqrt{F_A^2 + F_B^2} = \sqrt{9 \, N^2 + 16 \, N^2} = 5 \, N \]

\[ \alpha = \frac{F}{m} = \frac{5 \, N}{5 \, kg} = 1 \, \frac{m}{s^2} \]

\[ \tan \theta = \frac{3}{y} \quad \theta = \tan^{-1} \left( \frac{3}{y} \right) = 36.9^\circ \]

or \[ \tan \theta_1 = \frac{y}{3} \quad \theta_1 = \tan^{-1} \left( \frac{y}{3} \right) = 53.1^\circ \]
8. A dog runs horizontally with a speed of 5.0 m/s off a platform that is 12.0 m above the surface of the water.

(a.) How much time elapses from when the dog leaves the edge of the platform until he strikes the water?
(b.) What is the horizontal distance from the edge of the platform to the point where the dog strikes the water?
(c.) What is the vertical component of the velocity just before the dog strikes the water?

\[ h = \frac{gt^2}{2} \]
\[ t^2 = \frac{2h}{g} \]
\[ t = \sqrt{\frac{2 \times 12}{9.8}} = 1.56 \text{ s} \]

(b) \[ x = v_x t = \frac{5 \text{ m}}{\text{s}} \times 1.56 \text{ s} = 7.82 \text{ m} \]

(c) \[ v_y = gt = 9.8 \frac{\text{m}}{\text{s}^2} \times 1.56 \text{ s} = 15.3 \frac{\text{m}}{\text{s}} \]
9. A skier with a mass of 70 kg is accelerating down a 30° hill (Fig.).
(20 pts) Assuming the coefficient of kinetic friction $\mu_k = 0.05$ and neglecting air resistance find the following:

(a.) Make a force diagram for the problem.
(b.) What is the normal force acting on the skier?
(c.) What is the friction force acting on the skier?
(d.) What is the magnitude of his acceleration?

(Hint: direct x-axis of the reference frame down the hill and y-axis perpendicular to the slope and consider the components of forces)

\[ F_N - mg \cos 30° = 0 \]
\[ F_N = mg \cos 30° = 70 \text{ kg} \cdot 9.8 \frac{\text{m}}{\text{s}^2} \cos 30° = 594 \text{ N} \]

\[ F_{fr} = \mu_k F_N = 0.05 \cdot 594 \text{ N} = 29.7 \text{ N} \]

\[ mg \sin 30° - F_{fr} = ma \]
\[ a = \frac{mg \sin 30° - F_{fr}}{m} = g \sin 30° - \frac{F_{fr}}{m} = \]
\[ = 9.8 \frac{m}{s^2} \sin 30° - \frac{29.7 \text{ N}}{70 \text{ kg}} = 4.9 \frac{m}{s^2} - 0.424 \frac{m}{s^2} \]
\[ a = 4.48 \frac{m}{s^2} \]
A car rounds a flat unbanked curve with a radius $R=150\, \text{m}$. The coefficient of static friction is $\mu_s=0.80$.

(a.) Draw a free body diagram of the car.

(b.) What force provides the necessary centripetal acceleration in this case?

(c.) Write Newton's Law for vertical and horizontal components.

(d.) What is the maximum speed at which the driver can take the curve without sliding?

(e.) What is the centripetal acceleration when the car goes at this maximum speed?

\[
\begin{align*}
F_N & \quad \text{Friction force} \ F_{fr} \\
\downarrow W &= m g \\
\text{(c) } \quad F_{fr} &= m a_r \quad \text{horizontal} \\
F_N - mg &= 0 \quad \text{vertical}
\end{align*}
\]

\[
\begin{align*}
\text{(d) } a_r &= \frac{\nu^2}{R} \\
F_{fr} &= \mu_s F_N \\
\mu_s F_N &= m \frac{\nu^2}{R} \\
\nu^2 &= \mu_s g R \\
\mu_s mg &= m \frac{\nu^2}{R} \\
\nu &= \sqrt{\mu_s g R} = \sqrt{0.8 \times 150 \times 9.8} \\
&= 34.3 \, \text{m} / \text{s}
\end{align*}
\]

\[
\begin{align*}
\alpha_r &= \frac{\nu^2}{R} = \left( \frac{34.3 \, \text{m}}{3 \, \text{s}} \right)^2 = 7.84 \, \text{m} / \text{s}^2
\end{align*}
\]
The mass of the moon is about $\frac{1}{81}$ the mass of the Earth, its radius is $\frac{1}{4}$ that of the Earth, and the acceleration due to gravity at the earth's surface is $9.80 \text{ m/s}^2$. Use only this information to compute the acceleration due to gravity on the moon's surface. (Hint: Determine the ratio $\frac{g_m}{g_e}$ in your calculation.)

\[ mg_E = G \frac{m M_E}{r_E^2} \quad g_E = \frac{G M_E}{r_E^2} \]

\[ g_M = \frac{G M_E}{81 \left(\frac{r_E}{4}\right)^2} = \frac{G M_E}{81 \frac{r_E^2}{16}} = \frac{1}{16} \]

\[ \frac{g_M}{g_E} = \frac{1}{81} \frac{1}{16} \quad \rightarrow \quad g_M = g_E \frac{16}{81} = 1.935 \text{ m/s}^2 \]

1.936 m/s² or

1.94 m/s²

also correct