Physics 160 Test 2, Fall 2007, Dr. Morrison

Name______________________________

Questions worth 7 points each

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) A force of 1 N will cause a mass of 1 kg to have an acceleration of 1 m/s². Thus it follows that a force of 2 N applied to a mass of 2 kg will cause it to acquire an acceleration of:
   A) 2 m/s²  B) 0.50 m/s²  C) 3 m/s²  D) 1 m/s²  E) 4 m/s²

\[ F = ma \quad \Rightarrow \quad m = \frac{F}{a} = \frac{1 \text{ N}}{1 \text{ m/s}^2} = 1 \text{ kg} \]

Thus \[ a = \frac{F}{m} = \frac{2 \text{ N}}{2 \text{ kg}} = 1 \text{ m/s}^2 \]

2) A block is on a frictionless table, on earth. The block accelerates at 8.6 m/s² when a 10 N horizontal force is applied to it. The block and table are set up on the moon. The acceleration due to gravity at the surface of the moon is 1.62 m/s². The weight of the block on the moon is closest to:
   A) 1.2 N  B) 1.7 N  C) 0.95 N  D) 1.4 N  E) 1.9 N

\[
\text{(On Earth)} \quad m = \frac{F}{a} = \frac{10 \text{ N}}{8.6 \text{ m/s}^2} = \frac{10}{8.6} \text{ kg}
\]

\[
\text{(On Moon)} \quad \text{Weight} = F = mg = \left(\frac{10}{8.6} \text{ kg}\right)\left(1.62 \text{ m/s}^2\right) = 1.9 N
\]

3) A man pushes against a rigid, immovable wall. Which of the following is the most accurate statement concerning this situation?
   A) Since the wall cannot move, it cannot exert any force on the man.
   B) If the man pushes on the wall with a force of 200 N, we can be sure that the wall is pushing back with a force of exactly 200 N on him.
   C) The friction force on the man's feet is directed to the left.
   D) The man cannot be in equilibrium since he is exerting a net force on the wall.
   E) The man can never exert a force on the wall that exceeds his weight.
Three forces $A$, $B$, and $C$ act on a body as shown. The body is in equilibrium.

4) In Fig. 4.5, the $x$-component of force $F$ is closest to:
   A) $-28 \text{ N}$
   B) $+19 \text{ N}$
   C) $+32 \text{ N}$
   D) $-32 \text{ N}$
   E) $+28 \text{ N}$

\[ \sum F_x = 30 \text{ N} \cos 35^\circ + 50 \text{ N} \cos 40^\circ - 40 \text{ N} \cos 25^\circ \]

\[ = 19 \text{ N} \]

$\Rightarrow$ 19 N to the right
5) A box with weight 55 N is on a rough horizontal surface. An external force $F$ is applied horizontally to the box. A normal force and a friction force are also present, denoted by $n$ and $f$. A force diagram, showing the four forces that act on the box, is shown in Fig. 4.7. When force $F$ equals 2.0 N, the box is in motion at constant velocity. When force $F$ equals 2.6 N, the acceleration of the box is closest to:

A) 0.16 m/s$^2$  B) 0.15 m/s$^2$  C) 0.13 m/s$^2$  D) 0.11 m/s$^2$  E) 0.18 m/s$^2$

**Constant motion:**  
$F_n = F = 2N$

**Accelerating:**  
$\Sigma F = F - f = 3N - 2N \\ \Rightarrow ma \\ m = \frac{Weight}{g} = \frac{55N}{g} \\ \Rightarrow \alpha = \frac{2.6N - 2N}{(55N/g)} = \frac{0.6N}{55N/g} = \frac{0.6}{55}g = 0.11 m/s^2$

6) In Fig. 5.2, a block of mass $M$ hangs in equilibrium. The rope that is fastened to the wall is horizontal and has a tension of 55 N. The rope that is fastened to the ceiling has a tension of 63 N, and makes an angle $\theta$ with the ceiling. The angle $\theta$ is:

A) 61°  B) 45°  C) 76°  D) 29°  E) 41°

$\Sigma F_x = 0 = T_1 - T_2 \cos \theta \\ \Rightarrow \cos \theta = \frac{T_1}{T_2} = \frac{55N}{63N}$

$\Rightarrow \theta = 29^\circ$
Situation 5.1
A series of weights connected by very light cords are given an upward acceleration of 4.00 m/s² by a pull P, as shown in Fig. 5.3. A, B, and C are the tensions in the connecting cords.

Figure 5.3

7) In Situation 5.1, which statement is true about the tensions?
   A) \( P > C > B > A \)
   B) \( P = C \)
   C) \( P = A + B + C \)
   D) \( C + B = A \)
   E) \( A = B = C \)

8) A roadway is designed for traffic moving at a speed of 78 m/s. A curved section of the roadway is a circular arc of 190 m radius. The roadway is banked—so that a vehicle can go around the curve—with the lateral friction forces equal to zero. The angle at which the roadway is banked is closest to:
   A) 69°
   B) 75°
   C) 67°
   D) 73°
   E) 71°

\[
\begin{align*}
\Sigma F_y &= N \cos \theta - mg = 0 \quad \text{or} \quad N \cos \theta = mg \\
\Sigma F_x &= N \sin \theta = m \frac{v^2}{r} \\
\text{Divide} \quad \text{(Top into bottom)} \quad \Rightarrow \quad \tan \theta = \frac{v^2}{g} r &= \frac{(78 \text{ m/s})^2}{(9.8 \text{ m/s}^2)(190 \text{ m})} \\
\theta &= 73°
\end{align*}
\]
9) A ball of mass 3.0 kg is suspended by two wires from a horizontal arm, which is attached to a vertical shaft, as shown in Fig. 5.12. The shaft is in uniform rotation about its axis such that the linear speed of the ball equals 2.5 m/s. The tension in wire 2 is closest to:

A) 24 N     B) 44 N     C) 34 N     D) 39 N     E) 29 N

\[ \sum F_x = T_2 \cos \theta \Rightarrow m \frac{v^2}{r} \]

\[ T_2 = \frac{m v^2}{r \cos \theta} = \frac{(3\text{ kg})(2.5\text{ m/s})^2}{(0.8\text{ m}) \cos 36.9^\circ} = 29\text{ N} \]

10) A 5.00-kg point-mass is a distance \( d \) from a 20.0-kg point-mass. If the gravitational force on the smaller mass due to the larger one is 1.00 N, the gravitational force on the larger mass due to the smaller one is closest to:

A) 3.00 N     B) 1.00 N     C) 4.00 N     D) 0.250 N     E) 0.500 N
11) A satellite in a circular orbit of radius \( R \) around planet X has an orbital period \( T \). If Planet X had one-fourth as much mass, the orbital period of this satellite in an orbit of the same radius would be:

A) \( 2T \)  
B) \( T/4 \)  
C) \( T \sqrt{2} \)  
D) \( 4T \)  
E) \( T/2 \)

\[
T = \frac{2\pi R^{3/2}}{\sqrt{GM}}
\]  
(Kepler's 3rd Law)

\[
\frac{T_2}{T_1} = \frac{\frac{2\pi R^{3/2}}{\sqrt{Gm_2}}}{\frac{2\pi R^{3/2}}{\sqrt{Gm_1}}} = \sqrt{\frac{m_1}{m_2}} = \sqrt{4} = 2
\]

12) A satellite of mass \( m \) has an orbital period \( T \) when it is in a circular orbit of radius \( R \) around the Earth. If the satellite instead had mass \( 4m \), its orbital period would be:

A) \( 4T \)  
B) \( 2T \)  
C) \( T/4 \)  
D) \( T/2 \)  
E) \( T \)

Independent of mass of satellite

Table 12.1

<table>
<thead>
<tr>
<th></th>
<th>Mass</th>
<th>Radius</th>
<th>Orbital radius</th>
<th>Orbital period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moon A</td>
<td>4 x 10^{20} kg</td>
<td>2 x 10^8 m</td>
<td>2 x 10^8 m</td>
<td>4 x 10^6 s</td>
</tr>
<tr>
<td>Moon B</td>
<td>1.5 x 10^{20} kg</td>
<td>2 x 10^5 m</td>
<td>3 x 10^8 m</td>
<td></td>
</tr>
</tbody>
</table>

Ekaputo is an unknown planet that has two moons in circular orbits. The table summarizes the hypothetical data about the moons.

13) In Table 12.1, the mass of Ekaputo is closest to:

A) \( 1 \times 10^{23} \) kg  
B) \( 3 \times 10^{23} \) kg  
C) \( 3 \times 10^{22} \) kg  
D) \( 1 \times 10^{24} \) kg  
E) \( 1 \times 10^{22} \) kg

Use Kepler's 3rd Law

\[
T = \frac{2\pi R^{3/2}}{\sqrt{GM}} = 2\pi \sqrt{\frac{R^3}{GM}}
\]

4 Solve for mass:

\[
M = \frac{(2\pi)^2 R^3}{GT^2}
\]

Apply to Moon A:

\[
M = \frac{(2\pi)^2 (2 \times 10^8)^3}{(2\pi \sqrt{\frac{R^3}{GM}})^2} = 3 \times 10^{23} \text{ kg}
\]
14) The reason an astronaut in an earth satellite feels weightless is that
   A) the astronaut's acceleration is zero.
   B) the astronaut is falling.
   C) the astronaut is beyond the range of the earth's gravity.
   D) the astronaut is at a point in space where the effects of the moon's gravity and the earth's
      gravity cancel.
   E) this is a psychological effect associated with rapid motion.

15) A ball is dropped from rest and feels air resistance as it falls. Which of the graphs in Fig. 5.39 best represents its acceleration as a function of time?

Figure 5.39

(a) 

(d)

(b) 

(e)

(c)