I. A train consists of a locomotive and two railroad cars (see below), all having the same mass. The two cars, each with a mass of $10^4$ kg, are connected to each other. The locomotive is propelled forward at full power resulting in a $0.1 \text{ m/s}^2$ acceleration of the entire train. In the following assume that the frictional forces on the cars can be neglected.

\[ g = 10 \text{ m/s}^2 \text{, for simplicity} \]

a) Draw a force diagram for each car in the space below. Label all forces.

b) Find the magnitudes of all of the forces in your diagrams above.

c) What would the maximum acceleration of the train be if the locomotive were pulling three cars instead of two? \textit{Explain your reasoning.}
II. An 80-kg man uses an 8 meter long rope swing to cross a small stream. When he is directly under the rope support (when the rope is vertical) he releases the rope and then lands across the stream (see diagram at right.)

a) Based on the height at which he releases the rope and the width of the stream shown in the diagram, find the man’s velocity (magnitude and direction) just after he lets go of the rope.

\[ v = \text{______________} \]

direction = \text{______________}

b) Draw two force diagrams for the man (inside the rectangles provided): one when he is at point A and the other when he is further along his circular path at point B (label all forces.)

c) Determine the tension in the rope just before he releases it.

\[ Tension = \text{______________} \]
let \( g = 10 \text{ m/s}^2 \), for simplicity

3. Each of five different objects experience two forces, one in the +x direction and one in the +y direction (see table below.) The objects are initially at rest. Which object will subsequently speed up in a direction that is closest to 45° with the horizontal?

<table>
<thead>
<tr>
<th>Object</th>
<th>( F_1 ) (in Newtons)</th>
<th>( F_2 ) (in Newtons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>77</td>
<td>93</td>
</tr>
<tr>
<td>B</td>
<td>102</td>
<td>88</td>
</tr>
<tr>
<td>C</td>
<td>96</td>
<td>150</td>
</tr>
<tr>
<td>D</td>
<td>51</td>
<td>64</td>
</tr>
<tr>
<td>E</td>
<td>20</td>
<td>30</td>
</tr>
</tbody>
</table>

a) object A  
b) object B  
c) object C  
d) object D  
e) object E

4. A puck moves in the +x direction along a frictionless horizontal surface at a constant velocity. It receives a brief horizontal kick in a direction perpendicular to the velocity, which changes its direction of motion. In the diagram below you are looking down on the table from above. The main forces acting on the puck after receiving the kick are:

a) a downward force of gravity  
b) a downward force of gravity and a horizontal force in the direction of motion.  
c) a downward force of gravity, an upward force exerted by the surface, and a horizontal force in the direction of motion.  
d) a downward force of gravity, an upward force exerted by the surface.  
e) no forces act on the puck

5. The velocity as a function of time for an object is shown in the graph to the right.

Which graph below best represents the net force vs time for this object?
let $g = 10 \text{ m/s}^2$, for simplicity

6. Two spaceships are next to each other, both in the same circular orbit around the earth. The mass of the first spaceship is twice as big as the mass of the second spaceship. Which of the following quantities are the identical for the two spaceships?

<table>
<thead>
<tr>
<th>speed</th>
<th>acceleration</th>
<th>gravitational force</th>
<th>centripetal force</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>speed and centripetal force only</td>
<td>b) gravitational force and acceleration only</td>
<td>c) acceleration only</td>
</tr>
<tr>
<td>d)</td>
<td>speed and acceleration only</td>
<td>e) centripetal force and gravitational force only</td>
<td></td>
</tr>
</tbody>
</table>

7. An object with a mass $M = 0.25 \text{ kg}$ is at rest on a plane that makes an angle of $\theta = 30^\circ$ above the horizontal. The coefficient of kinetic friction between $M$ and the plane is 0.10. When the mass $M$ is attached by a string to another mass $m = 0.20 \text{ kg}$, which hangs freely, the system accelerates. When mass $m$ has fallen 0.30 m its speed is

a) 0.84 m/s  
b) 1.1 m/s  
c) 0.65 m/s  
d) 0.48 m/s  
e) 1.2 m/s

8. A planet X has a radius $R_X = R_{\text{earth}}/3$ and a mass $M_X = M_{\text{earth}}/2$. Find the free fall acceleration at the surface of planet X.

a) $g_{\text{earth}}/3$  
b) $g_{\text{earth}}/2$  
c) $9g_{\text{earth}}/2$  
d) $3g_{\text{earth}}/2$  
e) $4g_{\text{earth}}/3$