Name:

Physics 161 Final Exam Summer I ’01
7/13/2001 Jeff Simpson

There are 6 questions worth 20 points each with point breakdowns listed in square brackets. Show ALL your work. If you need more workspace, use the back of the same page and write a note indicating this.

1. A few questions
(a) [6 pts] Describe what is meant by an inertial and a non-inertial reference frame. Compare the two in terms of how an observer in each might apply Newton’s laws.

(b) [6 pts] How are linear and angular momentum related? When is linear momentum conserved? When is angular momentum conserved?

(c) [8 pts] An astronaut on a research mission to asteroid 1566, named Icarus, ponders whether she can escape the asteroid’s gravitational pull simply by jumping upwards from the surface. Icarus has a diameter of 1.4 km and a mass of 10^{12} kg and the universal gravitational constant \( G = 6.67 \times 10^{-11} \) N-m^2/kg^2. Calculate the escape speed of Icarus and comment whether a person might achieve this speed by jumping.
2. A puck of mass $m_1 = 0.30\text{kg}$ initially at rest on a horizontal, frictionless surface, is struck by a second puck of mass $m_2 = 0.20\text{kg}$. The second puck is moving initially with speed $v_i = 2.00\text{m/s}$ in the positive $x$ direction and after the collision moves with a speed $v_{2f} = 1.00\text{m/s}$ at an angle $\theta = 53.0^\circ$ from the positive $x$ axis.

(a) [8 pts] Determine the velocity of the first puck $m_1$ after the collision.

(b) [7 pts] Find the fraction of kinetic energy lost in the collision ($\Delta K/K_i$). Where does this energy go?

(c) [5 pts] What is the impulse delivered to puck $m_1$?
3. The velocity versus time graph for an object traveling along a straight line is given below. The initial position of the object at $t = 0$ s is 0 m.

(a) [7 pts] Graph the acceleration versus time on the bottom graph. Include numeric values on the acceleration axis (ordinate axis) to indicate the scale.

(b) [7 pts] Graph the position versus time on the top graph. Include numeric values on the position axis (ordinate axis) to indicate the scale.

(c) [6 pts] What is the value of the position at $t = 5$, 15, and 25 seconds?
4. Several constant forces are applied to a wheel as shown. Note $F_1$ is applied at an angle $\theta = 20^\circ$ relative to the tangent. The values of the radii are given by $r_1 = 30\, \text{cm}$ and $r_2 = 45\, \text{cm}$. The wheel has a mass $M = 2\, \text{kg}$ and can be considered to be a uniform disk of radius $r_2$.

(a) [5 pts] Find the net torque acting on the wheel. \textit{Reminder: torque is a vector.}

(b) [5 pts] If the torque in part (a) acts continuously on the wheel, which is initially at rest, find the angular speed after 3.0 seconds.

(c) [5 pts] How many revolutions does the wheel make during this time?

(d) [5 pts] What is the net work done on the wheel?
5. A wad of putty with mass \(m\) travels with initial speed \(v_i\). The putty hits and sticks to the end of a uniform rod of length \(l\) and mass \(M\). The rod is free to rotate in a horizontal plane about a fixed vertical axis through its center of mass. Where appropriate, express your answers in terms of \(m, M, v_i,\) and \(l\).

\[
\begin{array}{c}
\bullet \\
\text{m} \\
v_i \\
\text{M} \\
\end{array}
\]

(a) [3 pts] Find the initial angular momentum \(L_i\) of the putty about the axis of the rod. Be sure to specify magnitude and direction.

(b) [5 pts] Calculate the moment of inertia of the putty and rod about the axis of the rod.

(c) [6 pts] What is the final angular velocity \(\omega_f\) of the putty and rod? Remember that angular velocity is a vector.

(d) [6 pts] Suppose that after hitting the rod the putty did not stick but instead continued traveling in the same direction with speed \(v_f = \frac{1}{2} v_i\). Find the angular velocity of the rod in this case.
6. A cart of mass \( m \) is released from a height \( h \) such that it just makes the loop of radius \( R \) as shown. After the loop the cart slides off of the end of the track which is a distance \( H \) above the ground. The track is frictionless. Where appropriate, express your answers in terms of \( R, H, \) and \( g \).

\[ \begin{tikzpicture}
  \node [circle, draw] (R) at (0,0) {R};
  \draw[->] (R) -- (0,-2) node [midway, right] {H};
  \draw[->] (R) -- (0,2) node [midway, right] {h};
  \draw[->] (R) -- +(-2,0) node [midway, below] {d};
\end{tikzpicture} \]

(a) [6 pts] Find the initial height \( h \).

(b) [4 pts] What is the speed of the cart after completing the loop?

(c) [4 pts] Find the distance \( d \) where the cart lands.

(d) [6 pts] Label a two-component coordinate system for the cart’s motion after the end of the track. For each component sketch the position, velocity, and acceleration versus time.