You are subject to the Bryn Mawr College honor code while taking this exam. This is a closed book exam. You may use a simple calculator and a pencil during this exam, as well as both sides of a single page of notes. Do all questions on the exam. Do all work directly on the examination, in the space provided. If you run out of room, you may use the back of the page. Be sure to answer all parts of each question. Some problems will take longer than others, but all will be weighted equally when graded. When providing a sketch, please be as neat, accurate, and quantitative as possible. A sloppy sketch indicates misunderstanding and will receive a reduced grade. The final pages of this exam provide several potentially useful equations. You may remove these page for easy reference.

This exam will be available between Friday, 3 April 2015 and Wednesday, 8 April 2015, at the reserve desk in the Collier Science Library during normal library operating hours. I will collect all of the exams Thursday morning when the library opens. Take the exam during a single 90 minute sitting in the library.

Before you begin, write your name in the space below and at the top of EVERY page of this exam, note the date in the space provided on this page, and note the time. When you finish, note the time and return the exam to the circulation desk. The difference between your start and finish times should be no more that 90 minutes.

Name:

Date:

Start time:

Finish time:
1. A cowboy hat is resting on a table when struck by a bullet. The bullet enters the hat with speed $v_0$ and goes through, emerging on the other end with speed $v < v_0$. The bullet has mass $m$, and the hat has mass $M$. If the coefficient of kinetic friction between the surface of the table and the hat is $\mu_k$, find the distance $\Delta x$ by which the center of mass of the hat will be displaced when it comes to rest again.
2. Identical constant forces push two identical masses A and B continuously from a starting line to a finish line. If A is initially at rest and B is initially moving to the right, which mass has the larger change in momentum? Which mass has the larger change in kinetic energy? Explain your answers.
A 50-kg bungee jumper jumps from a bridge. She is tied to a bungee cord that is 10 m long when unstretched and has a spring constant of 50 N/m. How far below the bridge is she when she reaches her maximum speed? What is her maximum speed?
4. Two blocks of mass \( m \) and \( 3m \), resting on a frictionless table, are connected by a stretched spring and then released. (a) Is there a net external force on the system? (b) Determine the ratio of their velocities. (c) What is the ratio of their kinetic energies? (d) Describe the motion of the center of mass of the system.
Potentially useful equations

\[ v_x = v_{0x} + a_x t \]
\[ x = x_0 + v_{0x} t + \frac{1}{2} a_x t^2 \]
\[ v_x^2 = v_{0x}^2 + 2a_x (x - x_0) \]

\[ r = \mathbf{r} \]  
\[ \mathbf{v} = \dot{\mathbf{r}} + r \dot{\theta} \hat{\theta} \]  
\[ a = (\ddot{r} - r \ddot{\theta}) \hat{r} + (r \ddot{\theta} + 2 \dot{r} \dot{\theta}) \hat{\theta} \]

\[ a_c = \frac{v^2}{r} = \omega^2 r \]
\[ v = r \omega \]
\[ \omega = \frac{2 \pi f}{T} \]

\[ \mathbf{F} = m \mathbf{a} \]
\[ F_{\text{friction}} = \mu N \]
\[ W = mg \]
\[ F_s = -kx \]
\[ F_{\text{grav}} = \frac{GM_a M_b}{r^2} \]

for \( q + \omega^2 q = 0, \quad q(t) = A \sin(\omega t + \phi) \)

\[ \mathbf{A} \cdot \mathbf{B} = |\mathbf{A}| |\mathbf{B}| \cos \theta \]
\[ \mathbf{A} \cdot \mathbf{B} = A_x B_x + A_y B_y + A_z B_z \]
\[ |\mathbf{A} \times \mathbf{B}| = |\mathbf{A}| |\mathbf{B}| \sin \theta \]
\[ \mathbf{A} \times \mathbf{B} = \hat{i}(A_y B_z - A_z B_y) - \hat{j}(A_x B_z - A_z B_x) + \hat{k}(A_x B_y - A_y B_x) \]

\[ g = 10 \text{ m/s}^2 \]
\[ G = 6.673 \times 10^{-11} \text{ m}^3 \text{kg}^{-1} \text{s}^{-2} \]

for \( ax^2 + bx + c = 0, \quad x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \)
More potentially useful equations

\[ p = mv \]
\[ F = \frac{dp}{dt} \]
\[ \Delta p = \int F \, dt \]
\[ R = \frac{1}{M} \sum_i m_i r_i \]

\[ W_{ba} = \int_a^b F \cdot dr \]

\[ K = \frac{1}{2}mv^2 \]
\[ W_{ba} = K_b - K_a \]

\[ U_b - U_a = -\int_a^b F \cdot dr \]
\[ U_{spring} = \frac{1}{2}kx^2 \]
\[ U_{grav} = mgh \]
\[ U_G = -\frac{GMm}{r} \]

\[ p_1 + p_2 = p'_1 + p'_2 \]
\[ K_1 + K_2 = K'_1 + K'_2 \]
\[ v_1 - v_2 = v'_2 - v'_1 \]

\[ K + U = K' + U' \]
\[ W_{nc} = \Delta K + \Delta U \]