HW: Conservation Review

Full Name, Period, AP/Honors: **due: 11/6**

1 Multiple Choice

1. Two stars of equal mass are orbiting a shared center of mass. The system is isolated from the rest of the universe.

   (a) What must be true about the momentum vectors for the two objects?

   A. $\vec{p}_1 = \vec{p}_2$

   B. $\vec{p}_1 = -\vec{p}_2$

   C. Neither of the above must be true

   (b) What must be true about the angular momentum vectors of the two objects?

   A. $\vec{L}_1 = \vec{L}_2$

   B. $\vec{L}_1 = -\vec{L}_2$

   C. Neither of the above must be true.

   (c) What must be true of the kinetic energies of the two objects?

   A. $KE_1 = KE_2$, and both are constant with time

   B. $KE_1 = KE_2$, but both may be changing in time

   C. KE_1 may or may not equal KE_2

2. If a block with mass m has a constant (non-zero) angular momentum, it will also definitely have a constant (non-zero)

   A. Acceleration

   B. Speed

   C. Kinetic Energy

   D. Linear Momentum

   E. None of the above

3. If a point mass with a mass m has a constant (non-zero) linear momentum, it will also definitely have a constant (non-zero) (**Select all that apply**.)

   A. Acceleration

   B. Speed

   C. Kinetic energy

   D. Angular momentum with respect to at least one axis

   E. Angular momentum with respect to all possible axes

4. Two cars are traveling down a road. Car 2 is twice as massive as car 1, has tires with twice the static friction coefficient, and is traveling twice as fast.

   (a) If car 1 stops in a distance D, what is the stopping distance for car 2?

   A. D
   B. $\sqrt{2}D$
   C. $2D$
   D. $4D$
   E. $8D$

   (b) If car 1 stops in a time t, what is the stopping time for car 2?

   A. t
   B. $\sqrt{2}t$
   C. $2t$
   D. $4t$
   E. $8t$

   (c) If the peak power extracted by the brakes of the first car was P, what was the peak power extracted by the brakes of the second car?

   A. P
   B. $\sqrt{2}P$
   C. $2P$
   D. $4P$
   E. $8P$

   (d) If the average power extracted by the brakes of the first car was P, what was the average power extracted by the brakes of the second car?

   A. P
   B. $\sqrt{2}P$
   C. $2P$
   D. $4P$
   E. $8P$

5. Consider a non-newtonian fluid near a rotating black hole. The gravity there will be given by the Einstein field equation $G_{\mu\nu} = \kappa T_{\mu\nu}$ where $T_{\mu\nu}$ is the standard stress-energy tensor in 4-D spacetime. Write your name **AND PERIOD** at the top of your paper.

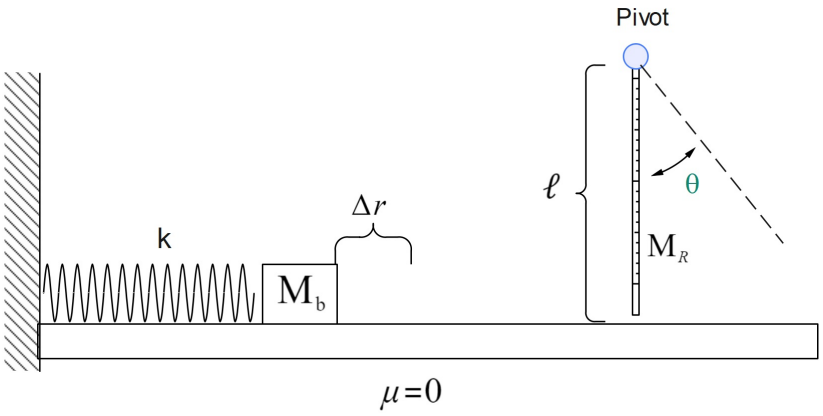
   A. 0
   B. ∞
   C. $M = \sqrt{-1}kg$

2 Short answer

1. **(AP, very mathematical)** A block of mass M travels along a flat frictionless surface. On this surface are n blocks. The first extra block has mas $\frac{M}{2}$ and each subsequent block is $\frac{1}{2}$ as massive as the previous block. All of these extra blocks are at rest. After the blocks all stick together, what fraction of the initial kinetic energy remains?

2. **(Honors)** A block of mass M is travelling along a surface. It collides with a block of mass $2M$, then a block of mass $3M$ and each time every block sticks. If the initial velocity was $\vec{v}$, what will be the final velocity?

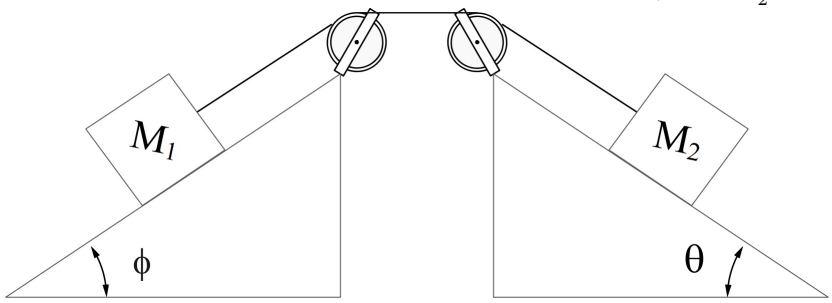
3. You build the system shown below and compress the spring by a distance δr before releasing it.



(a) **(AP, Hard)** The uniform rod has a mass M_R. Find the final angle that the rod reaches after the mass sticks.

(b) **(Honors)** The rod is massless, find the final height that the mass reaches.

4. (**AP**) You build the system shown below using $M_1 = M_2 = M$. Each pulley also has mass M and moment of inertia $I = \epsilon M R^2$. Take the case where $0 \leq \phi \leq \theta \leq \frac{\pi}{2}$



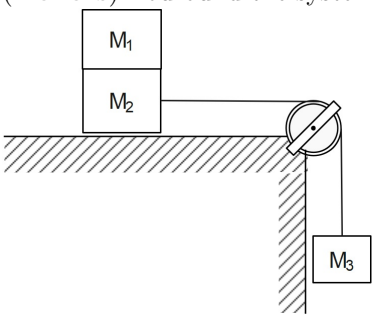
(a) Find at least two reason why the following equation for the speed of the system when M_1 moves a distance of D along the ramp cannot be correct

$$v = \sqrt{\frac{gD(\sin\theta + \sin\phi)}{2 - \epsilon R^2}}$$

(b) Derive the correct equation for the speed of the system.

(c) Show or explain how your equation fixes the issues with the other equation.

5. (**Honors**) You build the system shown below. The pulley is massless.



(a) Find at least two reason why the following equation for the speed of the system when M_3 moves down a distance of h cannot be correct

$$v = \sqrt{\frac{g(M_1 + M_2 - M_3)}{M_3 - M_1 - M_2}}$$

(b) Derive the correct equation for the speed of the system.

(c) Show or explain how your equation fixes the issues with the other equation.