Sample Midterm 3

You must show your work to get full credit.

1. A girl of mass \( m \) jumps on the edge of a playground carousel with speed \( v \) at an angle \( \theta \), as shown below (top view). Approximate the carousel by a solid circle of mass \( M \) and radius \( R \). Find the rotational speed of the carousel just after the girl lands on it. Assume that the carousel was at rest before the girl jumped on it, and that the girl moves with the carousel after she lands. The moment of inertia of the carousel is \( I = \frac{1}{2}MR^2 \).

![Diagram of a girl jumping onto a carousel](image)

2. An observer on the ground sees two trains of length \( L \) approaching each other with speed \( \frac{1}{2}c \). What is the length of each of the trains as seen by an observer on one of the trains? \( H \)int: Do this problem using the Lorentz transformation equations. Write an equation for the front and the back of each train in the ground frame, and then transform this into the frame of one of the trains.
3. A wire of mass $M$ is bent into the shape of a semicircle of radius $R$.

(a) Find the gravitational potential at the center of the semicircle.

(b) Find the gravitational force on a particle of mass $m$ at the center of the semicircle.