Physics 21 Midterm - 50 minutes

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Friday, Jan. 28

Write your answers in a blue book. Calculators and one page of notes allowed. No textbooks allowed. Please make your work neat, clear, and easy to follow. It is hard to grade sloppy work accurately. Generally, make a clear diagram, and label quantities. Make it clear what you think is known, and what is unknown and to be solved for. Except for extremely simple problems, derive symbolic answers, and then plug in numbers (if necessary) after a symbolic answer is available. **Put a box around your final answer... otherwise we may be confused about which answer you really mean, and you could lose credit.**

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1. The vectors $\boldsymbol{A}$ and $\boldsymbol{B}$ are defined as:

$$\boldsymbol{A} = 3\hat{\boldsymbol{\imath}} + 4\hat{\boldsymbol{\jmath}} \quad \boldsymbol{B} = -3\hat{\boldsymbol{\imath}} + 4\hat{\boldsymbol{\jmath}}$$

   (a) Numerically evaluate the dot product $\boldsymbol{A} \cdot \boldsymbol{B}$.

   (b) Use the result from (1a) to numerically evaluate the cosine of the angle from $\boldsymbol{A}$ to $\boldsymbol{B}$.

   (c) Numerically evaluate the cross product vector $\boldsymbol{A} \times \boldsymbol{B}$.

   (d) Use the result from (1c) to numerically evaluate the sine of the angle from $\boldsymbol{A}$ to $\boldsymbol{B}$.

2. The displacement from the origin of a particle is:

$$\boldsymbol{r}(t) = (2 - t)\hat{\boldsymbol{\imath}} + (-5 + 2t)\hat{\boldsymbol{\jmath}} - \frac{1}{2}t^2\hat{\boldsymbol{k}}$$

   (a) What is the velocity $\boldsymbol{v}(t)$?

   (b) What is the speed as a function of time t?

   (c) What is the acceleration $\boldsymbol{a}(t)$?

3. A block of mass m_1 sits on an incline which itself has mass m_2, as shown in Fig. 1. The angle in the lower right corner of the incline is θ. The incline sits on the floor, and the vertical surface of the incline at left is in contact with a wall. There is no friction between any pair of surfaces, and the whole setup is on earth, where the acceleration of gravity is approximately $g = 10\,\mathrm{m/s^2}$.

   (a) What is the acceleration of the block?

   (b) What force (vector) does the incline exert on the wall?

4. A dense ball, mass m, hangs by a massless string of length ℓ from the ceiling of a building on earth. The mass m rotates in a circle, so that the string sweeps out a cone with half angle θ. The situation is depicted in Fig. 2.

   (a) Determine the tension in the string.

   (b) Determine the speed of the dense ball.

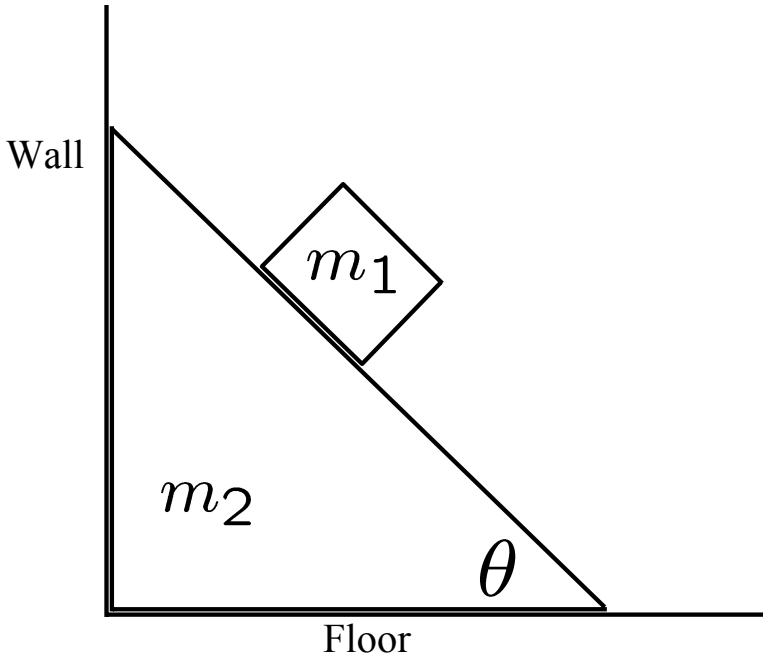

Figure 1: For use in problem 3.

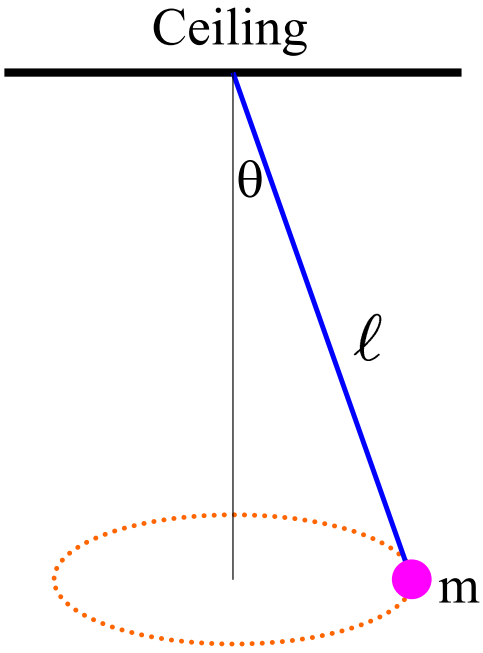

Figure 2: For use in problem 4.