Physics 191 17 October 1996 Exam 2

Answer any five (5) questions, in any order you wish. If you answer more than five questions, I will pick the best ones.

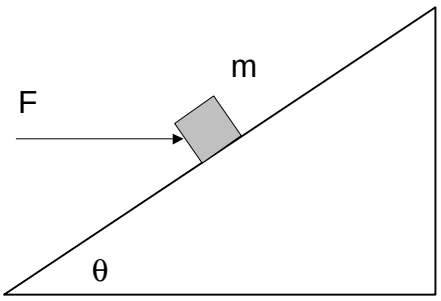
Answer each question carefully and in detail, and be careful of your use of units. Your answers will be judged on completeness and cogency of expression as well as accuracy.

Please write on only **ONE SIDE** of the paper, and begin each problem on a **NEW PAGE**.

Please turn in your help sheet with your exam.

SHOW ALL WORK! I can give partial credit only if I can tell how you arrive at your answers.

1. A block of mass *m* is on a plane surface inclined at an angle θ to the horizontal. A horizontal force F is applied to the block, as shown in the diagram. Assume that the mass is 5 kg and the angle 40°.

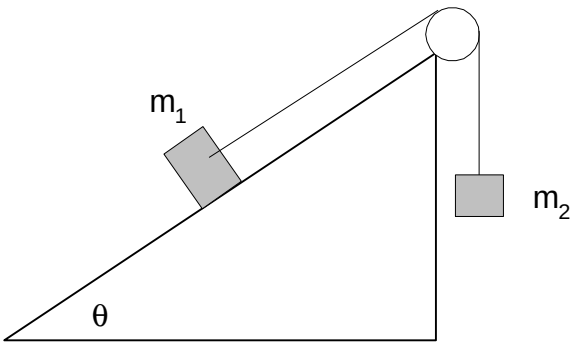


(a) Make a careful force diagram for mass *m*, clearly showing all forces that act (including kinetic friction if present). Assume that the force is large enough to accelerate the block up the plane.

(b) If friction is neglected, what horizontal force must be applied in order for the mass to accelerate up the plane at 2 m/s^2?

(c) If the coefficient of kinetic friction is 0.2, what horizontal force must be applied in order for the mass to accelerate up the plane at 2 m/s^2?

2. Consider two masses connected by a thin string, as shown in the diagram. Assume the plane is perfectly smooth (that is, friction-free).



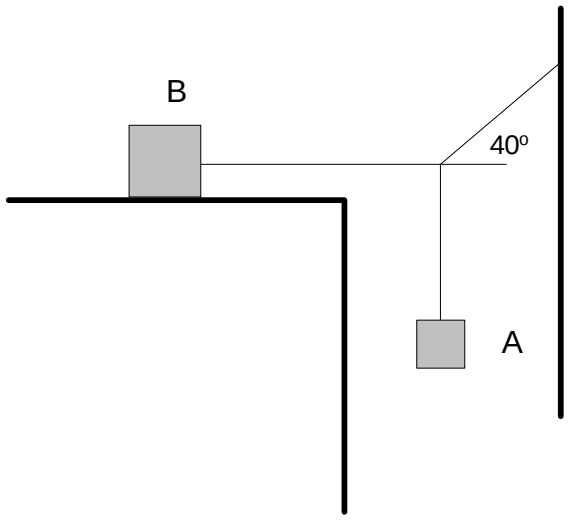
(a) Make careful force diagrams for both masses.

(b) Find the acceleration of the system (including direction) if m_1 = 8 kg, m_2 = 12 kg, and θ = 30°.

(c) For any angle, find a general result for the ratio of the masses if the system is to be at rest.

Hint: Part (c) will be easier and quicker if you do not substitute numbers in part (b) until the very last step.

3. Mass A is suspended from strings of negligible mass, as shown in the drawing. Assume mass B is 50 kg, and that the coefficient of static friction between mass B and the horizontal surface is 0.25.

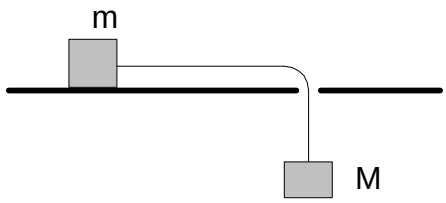


(a) Make a careful force diagram for both masses.

(b) Find the maximum mass for mass A for which the system will remain at rest.

Hint: At the point where the three strings come together, the vector sum of the three forces (tensions) must be zero. Why?

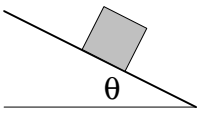
4. A mass *m* on a frictionless table is attached to a hanging mass *M* by a cord through a hole in the table, as shown in the diagram. Mass *m* moves in a circle with a constant speed of 2.5 m/sec. Mass *M* is at rest. Assume $M = 2m$.



(a) Make a careful force diagram for both masses.

(b) Find the radius of the circle in which mass *m* moves.

5. A circular curve of highway is designed for traffic moving at 60 km/hr (16.7 m/sec). (That is, at this speed, no frictional forces are needed to hold vehicles on the road.) The radius of the curve is 125 m. A cross-section of this highway is shown in the diagram.



(a) Make a careful force diagram showing all forces acting on the vehicle.

(b) Identify which component of which force holds the vehicle in circular motion. Briefly explain your answer.

(c) Find the angle θ needed to hold the vehicle on the track if the road is frictionless.

(d) Explain carefully what would happen if the car were moving at a faster or slower speed.

6. A physics student ties a 3 kg stone onto a string and whirls it in a vertical circle of radius 1.2 m. The string can support a maximum tension of 40 N; any more, and the string will break. The student slowly increases the speed of the stone until the string breaks.

   (a) Make a careful force diagram for the stone when it is

      (i) at the top of the circle.

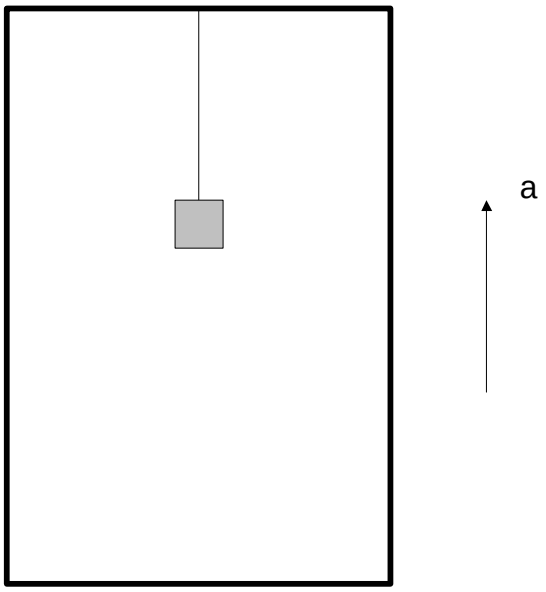
      (ii) at the bottom of the circle.

   (b) Where is the stone on its path when the string breaks? (You should have a good intuitive sense; but I also want a quantitative explanation.)

      Hint: Use your force diagrams for part (a) to write Newton's second law when the stone is at the top and bottom of the circle.)

   (c) What is the speed of the stone as the strong breaks?

7. A lamp hangs vertically from a cord in a descending elevator that is decelerating (that is, slowing down by accelerating upwards) at 2.1 m/s^2, as shown in the diagram.



   (a) If the tension in the cord is 85 N, what is the lamp's mass?

   (b) Is your answer to (a) intuitively reasonable (that is, do you expect the tension to be greater than, less than, or the same as the weight of the lamp)? Explain your answer carefully.

   Hint: Apart from the worked examples, we haven't done too many problems like this one. But you can approach it in the usual manner: Identify all the forces acting on the mass and apply Newton's second law.