Physics 191 **26 September 1996** **Exam 1**

Answer any five 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.

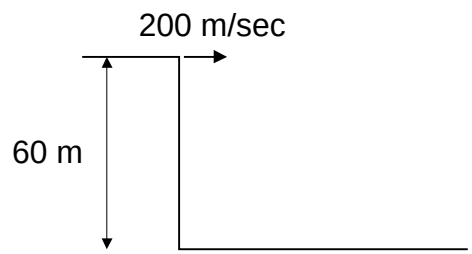
Please write on only **ONE SIDE** of the paper, and begin each problem on a **NEW PAGE**.

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 physics instructor is demonstrating centripetal acceleration by whirling a bucket of water in a vertical circle of radius 1.2 m. Assume that the speed of the bucket is constant.
   (a) What is the speed of the bucket if the centripetal acceleration is 35 m/sec^2?
   (b) How long does it take the bucket to make one full revolution?
   (c) At what minimum speed must the bucket move if the water is to remain in the bucket even at the top of its arc. Explain your answer to this part carefully and in detail.
2. Consider a vector $\vec{A}$ of length 50 units, oriented at an angle of 60º to the positive x-axis, and a second vector $\vec{B}$ of magnitude 30 units, oriented at an angle of 110º to the positive x-axis.
   (a) Find the components of $\vec{A}$ and $\vec{B}$ along the x- and y-axes, and express each vector in terms of the unit vectors $\hat{i}$ and $\hat{j}$.
   (b) Find $\vec{C} = \vec{A} - \vec{B}$ in terms of its components along the x- and y-axes, and express $\vec{C}$ in terms of the unit vectors $\hat{i}$ and $\hat{j}$.
   (c) Find the magnitude of $\vec{C}$ and its direction with respect to the positive x-axis.
   (d) Illustrate your answer with a careful diagram.
3. A rocket in a galaxy far, far away accelerates from rest, in a straight line, with a constant acceleration of 5.5 m/sec^2.
   (a) How long will it take the rocket to reach a speed one-tenth the speed of light. (The speed of light is 3×10^8 m/sec.)
   (b) How far will the rocket travel in this time?
4. A ball is thrown horizontally from a height of 20 m. It hits the ground with a speed that is three times its initial speed. What was its initial speed?

5. A projectile is launched horizontally from a platform that is 60 meters above flat ground. Its initial velocity is 200 m/sec.



(a) How long does the projectile remain in the air?

(b) How far does it go in a horizontal direction?

(c) What is its (vector) velocity an instant before it hits the ground?

2. An elevator without a ceiling is moving upwards at a constant speed of 15 m/sec. A physics student on the elevator throws a ball directly upward, from a height of 2.0 m above the elevator floor, just as the elevator floor is 28 m above the ground. The initial speed of the ball *with respect to the elevator* is 20 m/sec.

(a) What is the maximum height above ground level reached by the ball?

(b) Suppose on the way down, the ball falls through a hole in the elevator floor. How long does it take to hit the ground?

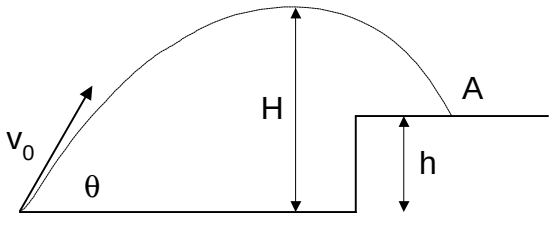
(c) How fast is the ball moving in the instant just before it hits the ground?

(d) How long does the ball take to return to the elevator floor (which, remember, continues to move up)? Note that you can do parts a, b, and c without doing part d.

Hint for part (d): Since the elevator is moving up at constant speed, one can express its height at a given time by the equation $Y = Y_0 + Vt$, where Y_0 = 28 m, the height of the elevator at the instant the ball is thrown, and $V = 15$ m/sec, the constant upward speed of the elevator. See if you can combine this equation with the equation that describes the motion of the ball to find the time at which the ball returns to the elevator floor.

Note: I will give substantial credit for the first three parts of this problem. If you don't at first see how to do part d, it might be a good idea to finish the rest of the exam before spending a lot of time on this part.

3. A stone is projected at a cliff of height *h* with an initial velocity v_0 of 40 m/sec, directed at $\theta = 65^o$ above the horizontal, as shown in the diagram. The stone strikes at A, 7.1 sec after launching.



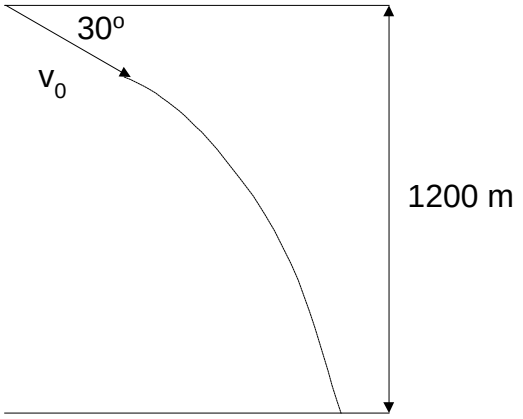
(a) What is the height *h* of the cliff?

(b) What is the maximum height *H* above ground reached by the stone?

(c) At what time or times will the stone be 50 m above ground level?

(d) What is the velocity of the stone just before it strikes at point A? (Express the velocity either in vertical and horizontal components, or in magnitude and direction.)

2. An airplane, diving at an angle of 30º below the horizontal, releases a projectile at a height of 1200 m above ground. The projectile hits the ground 6.0 sec after being released.



(a) What is the velocity of the aircraft? (Express the velocity in horizontal and vertical components.)

(b) How far does the projectile travel horizontally from its point of release?

(c) At what time after release does the projectile reach a height of 400 m above ground?

(d) What is the velocity of the particle at this time?