

Massachusetts Institute of Technology  
Physics Department

8.01

Fall 2004

**Exam #1 Solutions**

Grading instructions

- Each problem is worth 15 points. Please follow the allocations for each sub-part.
- Use the following general guidelines for grading each sub-part:
  - Full credit – everything correct and demonstrated understanding of the underlying concept. **A correct final answer does not necessary mean full credit.**
  - Half credit – demonstrated understanding of underlying concept, but algebraic errors or minor conceptual errors
  - No credit – nothing correct at all written; little or no demonstration of understanding of concepts.

## 1. Kinematics (15 points)

a. (5 points) The particle accelerates uniformly from  $t=0-3s$  and

$a=(6m/s)/3s=2m/s^2$ , so  $x(t) = \frac{1}{2}at^2 \Rightarrow x(3s) = 9m$ . From  $t=3$  to 5 s, the particle moves with a constant velocity of 6m/s, so  $x(5s)=12m+9m=21m$ .

b. (5 points) From the last part,  $a(1s)=2m/s^2$ .

c. (5 points)  $\langle v \rangle = \frac{21m}{5s} = 4.2m/s$

## 2. Runner catches bus (5 points)

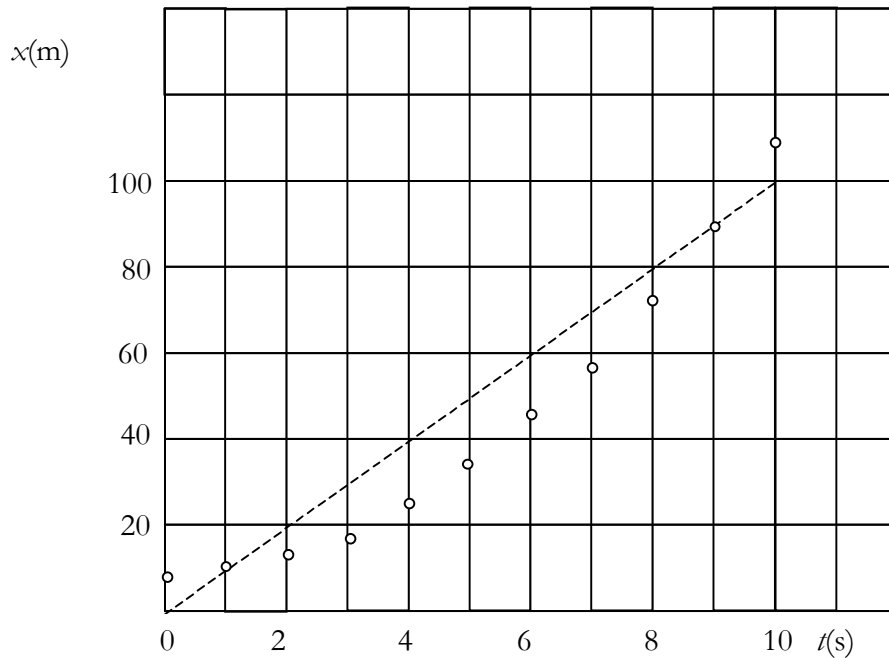
a. (3 points) The trajectory for the man is  $x_m(t) = (10m/s)t$ . The bus begins accelerating at  $t=0$  when the man is 9 m away, so the equation for the bus is

$$x_b(t) = \frac{1}{2}(2m/s^2)t^2 + 9m. \text{ The man catches the bus when}$$

$x_b(t) = x_m(t) \Rightarrow (10m/s)t = \frac{1}{2}(2m/s^2)t^2 + 9m$ . You can either solve the quadratic equation or just look at it and see the solution is  $t=1s$ , so he does catch the bus.

b. (4 points) From above, he catches the bus 1 s after starting to run.

c. (4 points)  $x_b(1s) = 10m$ , so the bus actually travels 1 m from its



starting point.

d. (2 points) See above

e. (2 points) The second opportunity occurs at  $t=9s$ . You can find this by solving the quadratic equation is just by seeing that it

$$\text{factors: } 0 = \frac{1}{2}(2m/s^2)t^2 - (10m/s)t + 9m = t^2 - 10t + 9 = (t-1)(t-9).$$

At  $t=9s$ , the man (and bus) is at or  $x_{man}(9s) = (10m/s)9s = 90m$ . The bus travels 81 m from its starting point (9 m relative to the man.)

### 3. Ballistic motion (15 points)

a. (8 points) The trajectory must go through the point  $(x,y)=(99\text{m},7\text{m})$ .

The general parametric equations are

$$\begin{aligned} x(t) &= \frac{3}{5}v_0 t \\ y(t) &= -\frac{1}{2}gt^2 + \frac{4}{5}v_0 t \end{aligned} \Rightarrow y(x) = \frac{4x}{3} - \frac{25gx^2}{18v_0^2} \Rightarrow v_0 = 5x \sqrt{\frac{g}{6(4x-3y)}} = 33\text{m/s}$$

b. (7 points) The particle travels 99m at  $(3/5)33\text{m/s}$ , which gives 5s.

#### 4. Vectors and $F=ma$ (15 points)

a. (4 points)  $\vec{F}_1 = 100N((3/5)\hat{i} + (4/5)\hat{j})$  and the net force is  $\vec{F}_N = 5kg \times 12m/s^2\hat{i} = 60N\hat{i} = \vec{F}_1 + \vec{F}_2$ . Then  $\vec{F}_2 = -80N\hat{j}$ .

b. (4 points) The problem is one dimensional and

$$x(t) = \frac{1}{2}(12m/s^2)t^2 \Rightarrow x(10s) = 600m.$$

c. (4 points)  $v_x(t) = (12m/s^2)t \Rightarrow v_x(10s) = 120m/s$ .

d. (4 points)  $\vec{F}_3 = -(5kg)(12m/s^2)\hat{i} = -60N\hat{i}$