Exam 1 (September 27, 2001)

Please read the problems carefully and answer them in the space provided. Write on the back of the page, if necessary. Show all your work. Partial credit will be given.

Problem 1 (20 pts):

A Boeing 727 jet takes off from the Rochester International Airport. It accelerates from rest for 32 seconds before leaving the ground. The jet accelerates at a constant 2.1 m/s^2.

a) What is the speed of the plane when the wheels leave the ground?

$$V = V_0 + at$$

$$V = 0 + (2.1 \, m/s^2)(32 \, s) = 67.2 \, m/s$$

b) What is the distance covered by the plane as it rolls on the runway gaining speed to take off?

$$X = X_0 + \left(\frac{V_0 + V}{2}\right) t$$

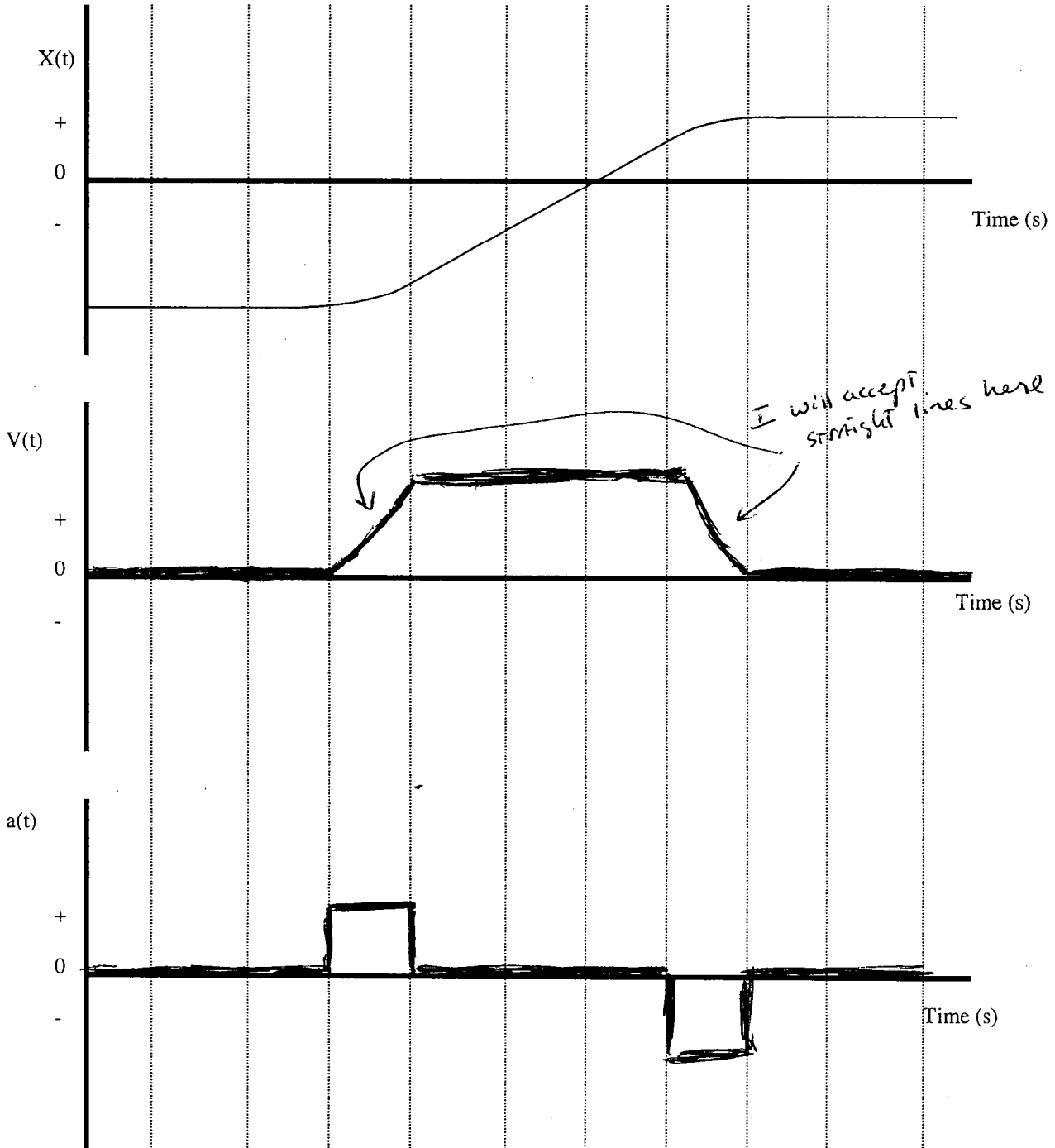$$X - X_0 = \left(\frac{67.2}{2}\right) 32 = 1075.2 \, M$$

$$\underline{or}$$

$$X = X_0 + V_0 t + \frac{1}{2} a t^2$$

$$X - X_0 = \frac{1}{2}(2.1)(32)^2 = 1075.2 \, M$$

Problem 2 (20 pts):

Below you are shown a graph of the position versus time for an object in motion.
Qualitatively plot the velocity versus time and acceleration versus time for this object on the
graphs provided.

X(t)

+

0

-

Time (s)

V(t)

I will accept straight lines here

+

0
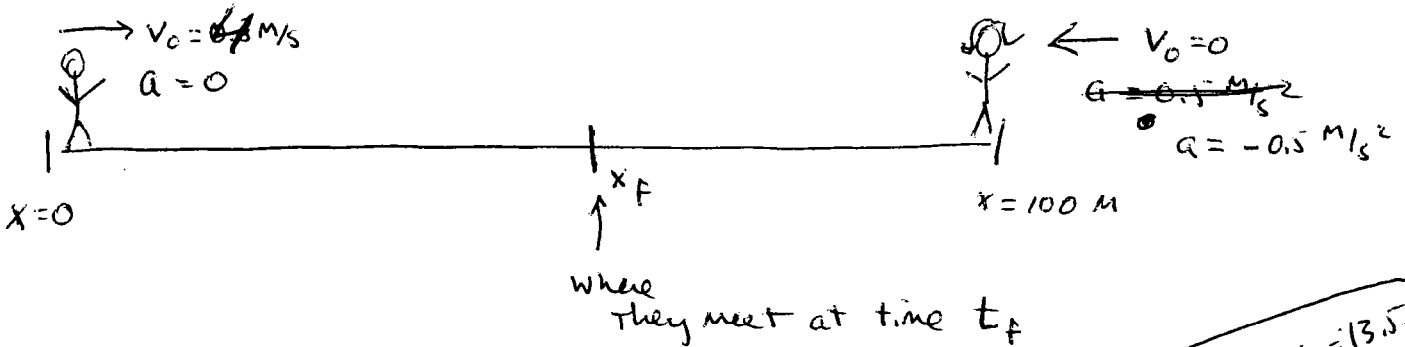
-

Time (s)

a(t)

+

0

-

Time (s)

Problem 3 (20 pts):

Sammy the sailor arrives in his home port after a long mission at sea. He spies his girlfriend at the other end of the pier. She sees him at the same time. They rush toward each other. (It's been a *long* time, okay?!) The pier is 100m long. Starting from rest, Sammy's girlfriend rushes toward him accelerating at a constant 0.5 m/s². Sammy is moving at a constant speed toward his girlfriend when he steps off the boat onto the end of the pier and sees her. He tries to speed up, but the duffle bag he is carrying is too heavy. His speed remains constant at 4 m/s.

a) How long after the moment they spot each other do the young lovers embrace?
b) Where do they meet on the pier relative to the end where Sammy started?

1)	/20
2)	/20
3)	/20
4)	/20
5)	/20
tot	/100

$\longrightarrow V_c = 4 \, m/s$
$a = 0$

$\longleftarrow V_o = 0$
$a = -0.5 \, m/s^2$

$X = 0$ x_f $X = 100 \, M$

where they meet at time t_f

Consider Sammy's Motion:

$$x_f = \cancel{x_0} + V_c t + \cancel{\frac{1}{2} a t^2}$$

$$\boxed{x_f = 4 \, t_f} \quad (I)$$

They meet at $x_f = 54 M$ at $t = t_f = 13.5 s$ after spotting one another

$$x_f = (4)(13.5 \, s) = \boxed{54 \, M}$$

Consider Sammy's girlfriend:

She moves from $x = 100$ to $x = x_f$ in time $t = 0 \to t = t_f$

$$x = x_0 + \cancel{v_0 t} + \frac{1}{2} a t^2$$

$$\boxed{x_f = 100 - \frac{1}{2}(0.5) t_f^2} \quad (II)$$

Have 2 eqns, 2 unknowns ... Solve simultaneously

Sub (I) in (II) $4 t_f = 100 - \frac{1}{2} 0.5 t_f^2$

$$t_f^2 + 16 t_f - 400 = 0 \to \text{quadratic in } t_f$$

$$t_f = \frac{-16 \pm \sqrt{16^2 + (4) \, 400}}{2}$$

$$t_f = 13.5 \, s$$

$T_f = 13.5$

or

TAKE positive Root

Problem 4 (20 pts, no partial credit given on this problem):

In the blank beside each statement, write a "T" if the statement is always true and an "F" if the statement is always or sometimes false.

a) __T__ An object can have zero velocity and still be accelerating.

b) __F__ The velocity of an object eventually reverses direction if the acceleration is constant.

c) __F__ An object can have constant velocity and still have a varying speed.

d) __T__ An object can have a positive velocity and zero acceleration.

e) __F__ An object with a positive velocity must have a positive position.

Problem 5 (20 pts):

Alvin the fly takes a morning dip in a customer's double expresso at a local donut shop. Alvin emerges from the coffee feeling refreshed and zips off through an open window with great gusto! Starting from rest at t=0, Alvin flies in a straight line away from the cup with a speed given by $v=Bt^2$, where B is a constant equal to 3 m/s^3.

a) How far from the cup is the fly after 2 seconds?

$$X = X_0 + \int_0^{t=2} Bt^2 \, dt$$

$$X - X_0 = dist.\ from\ cup = \left. \frac{Bt^3}{3} \right|_0^2 = (3) \frac{2^3}{3} \frac{M}{s^3} s^3 = 8M$$

b) What is the average acceleration of the fly over the interval from 0 to 2 seconds?

$$ave\ accel. = \frac{\Delta v}{\Delta t} = \frac{V(t=2) - V(t=0)}{(t=2) - (t=0)} = \frac{B(4-0)}{2} = \frac{(3)(4)}{2} = 6 \frac{M}{s^2}$$