SCIENCE/ENGINEERING PHYSICS - TEST CHAPTER 2
MOTION IN ONE DIMENSION - 100 PTS - 1993-94

OF THE FOLLOWING PROBLEMS YOU MUST DO FOUR [4]! BE SURE TO SHOW ALL WORK CAREFULLY! AN EXTRA PROBLEMS MAY BE DONE AS A 5 POINT BONUS - THE BONUS PROBLEM MUST BE CLEARLY INDICATED!

1. A speeding car is traveling South on Route 9 with a velocity of 62.0 m/s when it passes a Police car also heading South but with a velocity of 18 m/s. Just as the police car passes the speeder, the police officer "hits the gas" and accelerates at the rate of 7.2 m/s^2 until the police car reaches its maximum speed of 76 m/s. The police car continues at this speed until it is 100 meters behind the speeder. At that instant the speeder "hits the brakes" and skids to a halt. The police officer sees the speeder's brake lights and "hits the brakes" 2.0 seconds after the speeder [because of human reaction time!]. Both cars skid to a halt with an acceleration of -8.2 m/s^2.
   a. Sketch a graph plotting the position of both the speeder and police car as a function of time. Be sure to indicate on the graph "critical" points where changes occur! [5 pts]
   b. How long will it take for the police car to reach the point 100 meters behind the speeder? [5 pts]
   c. How far does the police car skid, from the time the brakes were applied until the police car stops? [5 pts]
   d. How far from the point where the speeder passed the police car will the police car catch up with the speeder? [5 pts]
   d. What will be the velocity of the police car when it catches up with the speeder? [5 pts]

2. The following data were collected from a freefalling object attached to a tickertape. Assume that the error on the time is insignificant.

D (m +/- .004)	t (s)
0.000	0.0
0.026	0.1
0.101	0.2
0.230	0.3
0.406	0.4
0.638	0.5
0.920	0.6
1.230	0.7
1.641	0.8

   a. Complete the appropriate data table predicting the velocity and acceleration of this falling object as a function of time. [5 pts]
   b. Based on the information supplied, what would be the appropriate errors on the calculated velocities and accelerations? [5 pts]
   c. Based on these data, determine the set of equations describing the position, velocity and acceleration of this falling object. [5 pts]
   d. Using the displacement equation you determined above predict the position of this falling object at t = .60 seconds and compare this to the measured displacement on an appropriately labeled bar graph. [5 pts]
   e. Write an appropriate conclusion based on the displacement bar graph generated above. [5 pts]

3. A hot air balloon is initially at rest on the ground. At t = 0 the ropes holding the balloon are released and the balloon accelerates upward at 1.25 m/s^2 until it reaches its maximum upward velocity of 8.50 m/s. Exactly 15.0 seconds after the balloon is released a sand bag is accidentally dropped from the balloon while at the same time a projectile is fired upward from the ground with an initial velocity of 86.0 m/s.
   a. What will be the height of the balloon just as the sand bag is released? [5 pts]
   b. What will be the maximum height of the sand bag above the ground? [5 pts]
   c. What will be the velocity of the sand bag when it is struck by the projectile? [5 pts]
   d. What will be the distance between the sand bag and the balloon when it is struck by the projectile? [5 pts]
   e. What will be the relative velocity between the projectile and the sand bag when they meet? [5 pts]

[CONTINUED ON OTHER SIDE!]

4. The acceleration of a moving object is given by the equation;

$$a = 5 \text{ m/s}^2$$

When t = 5.0 sec. this object is at d = 10.0 m and it is moving with a velocity of -30.0 m/s.

a. Write the equations describing the velocity and displacement of this object as functions of time. [5 pts]

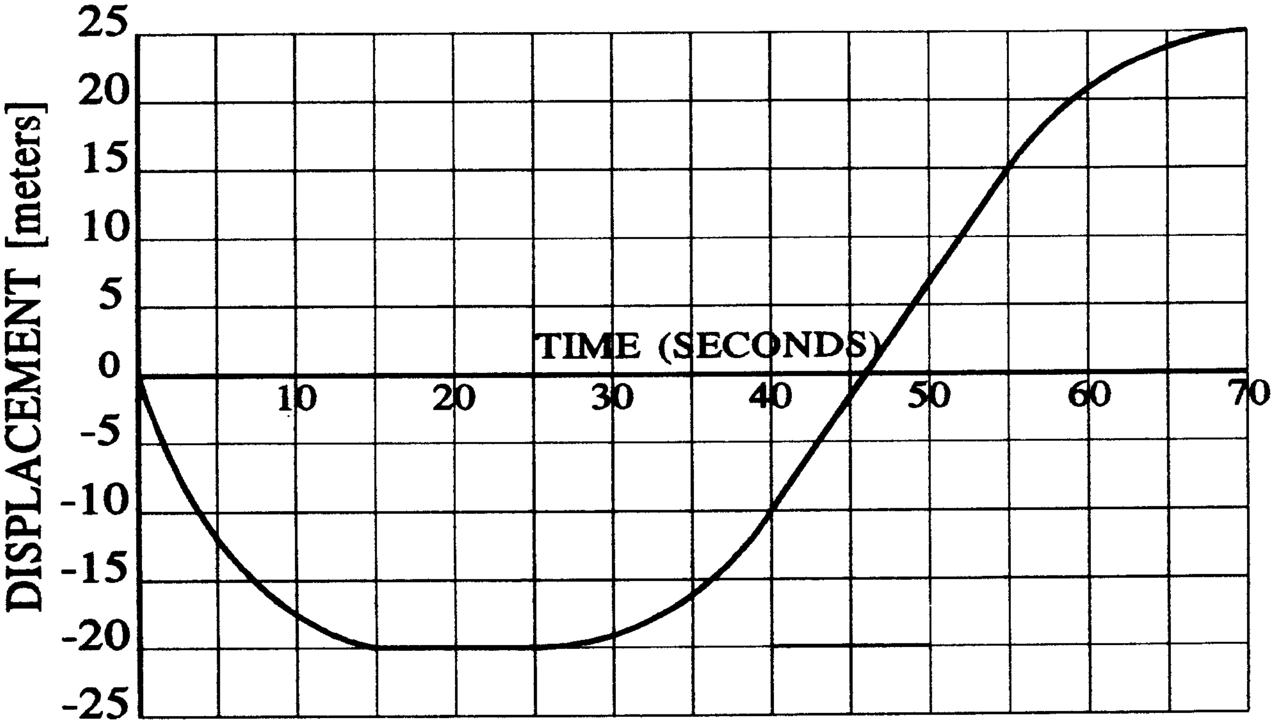
b. Sketch the graphs showing the position, velocity and acceleration of this object as a function of time from t = -20 to t = 40 seconds. Be sure to indicate all critical points on each graph! [5 pts]

c. **Using your velocity - time graph** from above determine the displacement of this object between t = 10 seconds and t = 25 seconds. [5 pts]

d. **Using your displacement - time graph** from above determine the instantaneous velocity of this object at t = 10 seconds. [5 pts]

e. **Using your acceleration-time graph** determine the velocity of this object at t = 5.0 seconds. [5 pts]

5. The graph below plots the velocity of a moving object as a function of time.



a. During which interval/intervals will the speed of this object at a maximum? Explain! [4 pts]

b. During which interval/intervals will this object have zero acceleration? Explain! [3 pts]

c. During which interval/intervals will this object be at rest? Explain! [3 pts]

d. During which interval/intervals is the velocity of this object increasing? Explain! [3 pts]

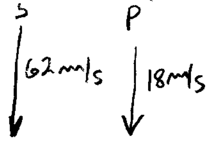
e. During which interval/intervals will the velocity of this object be at a minimum? Explain! [3 pts]

f. During which interval/intervals will the velocity of this object be constant? Explain! [3 pts]

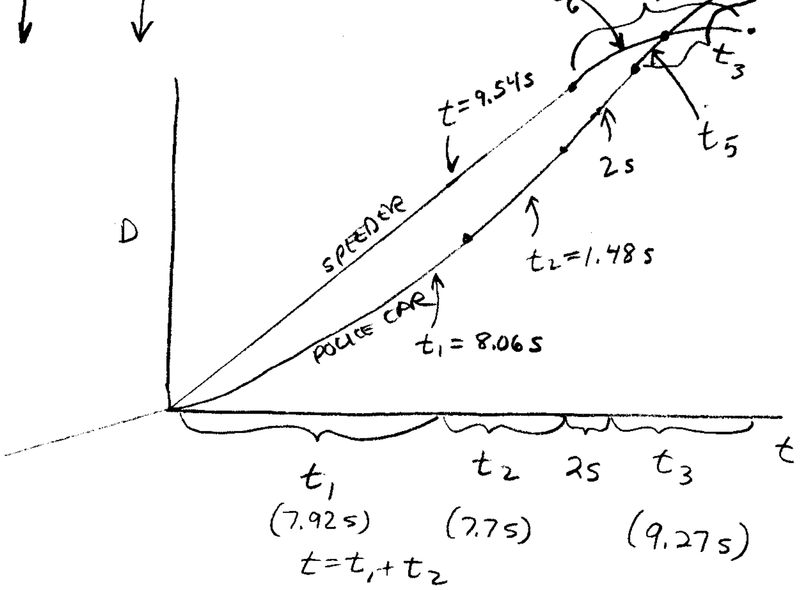
g. What will be the velocity of this object at t = 45 seconds? [3 pts]

h. During which interval/intervals is the acceleration of this object decreasing? Explain! [3 pts]

1.



$a_p = 7.2\ m/s^2$, $v_s = 76\ m/s$



(b) $D_s = 62(t)$

$D_p = \frac{1}{2}(7.2)t_1^2 + 18t_1 + 76t_2$

$t_1 \Rightarrow v_s = at + v_0$

$76 = 7.2t_1 + 18$

$t_1 = 8.06\ s$

$62t = 3.6(8.06)^2 + 18(8.06) + 100 + t_2(76)$

$t_2 = t - t_1 = (t - 8.06) = 9.54 - 8.06$

$t_2 = 1.48s$

$62t = 479 + 76(t - 8.06)$

$62t = 479 + 76t - 613$

$14t = 133.6$

$\boxed{t = 9.54s}$ (b) 5

$t = 9.54s$
$t_1 = 8.06s$
$t_2 = 1.48s$
$t_3 = 9.27s$
$t_4 = 7.56s$

(c) $D = \bar{v}t = \frac{76+0}{2}t_3$ $\quad 0 = -8.2t_3 + 76$

$t_3 = 9.27s$

$= 38(9.27)$

$\boxed{= 352m}$ (c) 5

$0 = -8.2t_4 + 62$

$t_4 = 7.56s$

(d) $D_{TOTAL\ (POLICE\ CAR)} = \frac{1}{2}7.2(8.06)^2 + 18(8.06) + 1.48(76) + 2(76) + \frac{1}{2}(-8.2)t_5^2 + 76t_5 = 770\ m$

$9.54 + t_6 = 8.06 + 1.48 + 2 + t_5 \qquad t_6 - t_5 = 2.0$

$D_{TOTAL\ (SPEEDER)} = 62(9.54) + \left[-\frac{8.2}{2}t_6^2 + 62t_6\right]$

$= 62(9.54) + [-4.1(3.86)^2 + 62(3.86)]$

$\boxed{= 770m}$ (d) 5

$643 - 4.1t_5^2 + 76t_5 = 591 - 4.1t_6^2 + 62t_6$

$t_6 = 2 + t_5$

$52 - 4.1t_5^2 + 76t_5 = -4.1(2+t_5)^2 + 62(2+t_5)$

$52 + 76t_5 + 124 + 62t_5 - 4.1t_5^2 + 4.1(2+t_5)^2$

$176 + 138t_5 - 4.1t_5^2 + 4.1(4 + 4t_5 + t_5^2)$

$176 + 138t_5 + 16.4 + 16.4t_5 = 0$

$t_5 = 1.86s$

$t_5 = t_6 - 2$

$t_6 = t_5 + 2$

$t_6 = 1.86 + 2 = 3.86s$

(e) $v = 76 - 8.2(t_5 + 2) = 76 - 8.2(1.86 \times 2) = \boxed{44.3m/s}$ (e) 5

2. (a)

t	$D \pm .004$	v	a
0	0		
		.260	
.1	.026		4.90
		.750	
.2	.101		5.40
		1.290	
.3	.230		4.70
		1.760	
.4	.406		5.10
		2.320	
.5	.638		5.00
		2.820	
.6	.920		2.80
		3.100	
.7	1.230		10.10
		4.110	
.8	1.641		

$\bar{a} = 5.5\ m/s^2$
$\pm .5$

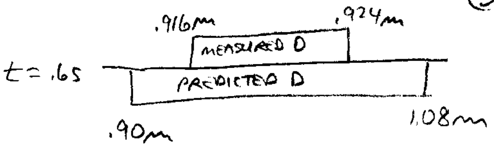
(b) $v = \frac{.004 + .004}{.1} = .08\ m/s$ (b)

$a = \frac{.08 + .08}{.1} = 1.6\ m/s^2$

(c)
$D = \frac{1}{2}5.5t^2\ (m)$
$v = 5.5t\ (m/s)$
$a = 5.5\ (m/s^2)$
(c)

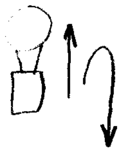
(d) $D = \frac{5.5}{2}(.6)^2 = .99m \pm .09$

(5 PTS)



(e) CONCLUSION (5 PTS)

3. $a = 1.25\ m/s^2$, $v_s = 8.5\ m/s$



ⓐ $v_s = at_1$

$8.5 = 1.25 t_1$

$t_1 = 6.8\ s$

$D = \frac{1}{2}at_1^2 + v_s t_2$

$= \frac{1.25}{2}(6.8)^2 + 8.5(15 - 6.8)$

$= 28.9 \quad 69.7$

$= \boxed{98.6\ m}$ ⓐ

ⓑ $D = \frac{1}{2}at^2 + v_0 t + D_0$

$= -4.9t^2 + 8.5t + 98.6$

$v = at + v_0$

$0 = -9.8t + 8.5$

$t = \frac{8.5}{9.8} = .87\ s$

$= -4.9(.87)^2 + 8.5(.87) + 98.6$

$= \boxed{102.3\ m}$ ⓑ

ⓒ $D_s = -4.9t^2 + 8.5t + 98.6 \qquad D_p = -4.9t^2 + 86t$

~~$-4.9t^2$~~ $+ 8.5t + 98.6 =$ ~~$-4.9t^2$~~ $+ 86t$

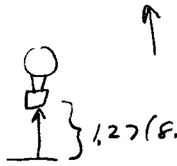
$77.5t = 98.6$

$t = \frac{98.6}{77.5} = 1.27\ s$

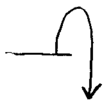
$v_s = at + v_0$

$= -9.8(1.27) + 8.5 = \boxed{-3.95\ m/s}$ ⓒ

ⓓ



x_0 } $1.27(8.5) = 10.8\ m$



$D_s = -4.9(1.27^2) + 8.5(1.27)$

$= 2.9\ m$

$\Delta X = 10.8 - 2.9$

$= \boxed{7.9\ m \text{ APART}}$ ⓓ

ⓔ $v_p = -9.8(1.27) + 86 = 73.6\ m/s$

$v_R = v_s - v_p = 73.6 + 3.95 = \boxed{77.6\ m/s}$ ⓔ

4. $a = 5\ m/s^2$ at $t = 5$ $d = 10\ m$ + $v = -30\ m/s$

ⓐ $v = 5t + C_1$

$-30 = 5(5) + C_1$

$C_1 = -55$

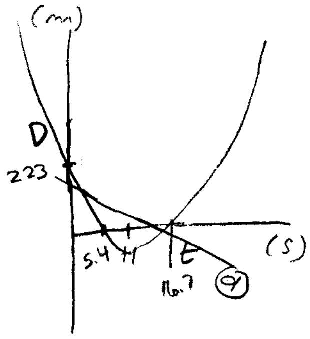
} $v = 5t - 55$

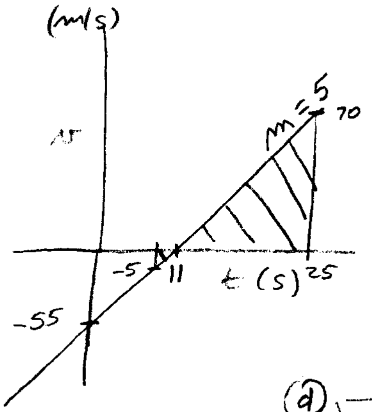
$d = \frac{5t^2}{2} - 55t + C_2$

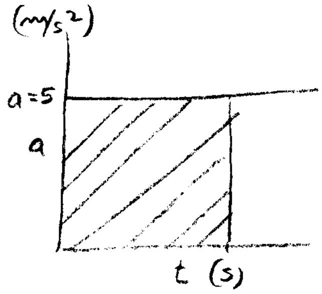
$10 = 2.5(5^2) - 55(5) + C_2$

$C_2 = 223$

} $d = 2.5t^2 - 55t + 223$







ⓒ

(USE AREA)

$\frac{1}{2}(25 - 11)(70) = 490\ m$

$+$

$-\frac{1}{2}(11 - 10)(5) = -2.5\ m$

} $\boxed{487.5\ m}$

ⓓ $\boxed{v = -5\ m/s}$

SLOPE OF TANGENT

ⓔ AREA

$= 5(5)$

$\boxed{v = 25\ m/s} + -55 \Rightarrow \boxed{-30\ m/s}$

5. ⓐ (0–5 s) STEEPEST SLOPE

ⓑ (15–25, 40–55 s) SLOPE CONSTANT

ⓒ (15–25) SLOPE = ZERO

ⓓ (0–15, 25–40) SLOPE GOING MORE POSITIVE

ⓔ (0–5) MOST NEGATIVE SLOPE

ⓕ (15–25, 40–55) SLOPE CONSTANT [SAME AS b]

ⓖ $v = \text{SLOPE} = \frac{\text{RISE}}{\text{RUN}} = \frac{25}{15} = 1.67\ m/s$

ⓗ (55–70) SLOPE DECREASING