NAME: KEY

MIDTERM 1: Physics 9A, Fall 2008

General Instructions/Information: This exam is closed book. Only a calculator is allowed. Please show all your work, and give units for all answers and on all graphs. Credit will only be given for complete solutions. The acceleration of gravity is g=9.8 m/s^2 downwards.

[1.] A turtle crawls along a straight line, which we will call the x-axis, with a positive direction to the right. The equation for the turtle's position is

$$x(t) = 80 \text{ cm} + 4 \text{ (cm/s)}\ t - 0.2 \text{ (cm/s}^2\text{)}\ t^2.$$

(a) Find the turtle's initial position, velocity, and acceleration. (b) At what time is the turtle's velocity zero? (c) How long after starting does the turtle return to its starting point?

a) $x(t) = 80 + 4t - .2t^2$ $\quad x(0) = 80$ cm

$dx/dt = v(t) = 4 - .4t$ $\quad v(0) = 4$ cm/s

$dv/dt = a(t) = -.4$ $\quad a(0) = -.4$ cm/s^2

b) $v(t) = 0 = 4 - .4t \rightarrow t = 10$ sec

c) $80 = 80 + 4t - .2t^2 \rightarrow 0 = t(4 - .2t)$

$\rightarrow t = 0$ or $t = 20$ sec

[2.] An automobile accelerates from rest at 4 m/s^2 for 10 s. The speed is then held constant for 6 s, after which there is an acceleration -2 m/s^2 until the automobile stops. What is the total distance traveled? Draw plots of the displacement, velocity, and acceleration as a function of time. Label your graphs with appropriate numbers.

First 10 seconds $x = x_0 + v_0 t + \frac{1}{2} a t^2$

$= 0 + 0t + \frac{1}{2} 4 (10)^2 = 200$ m

Next 6 seconds $x = x_0 + v_0 t + \frac{1}{2} a t^2$

$= 200 + 40(6) + 0 = 440$ m

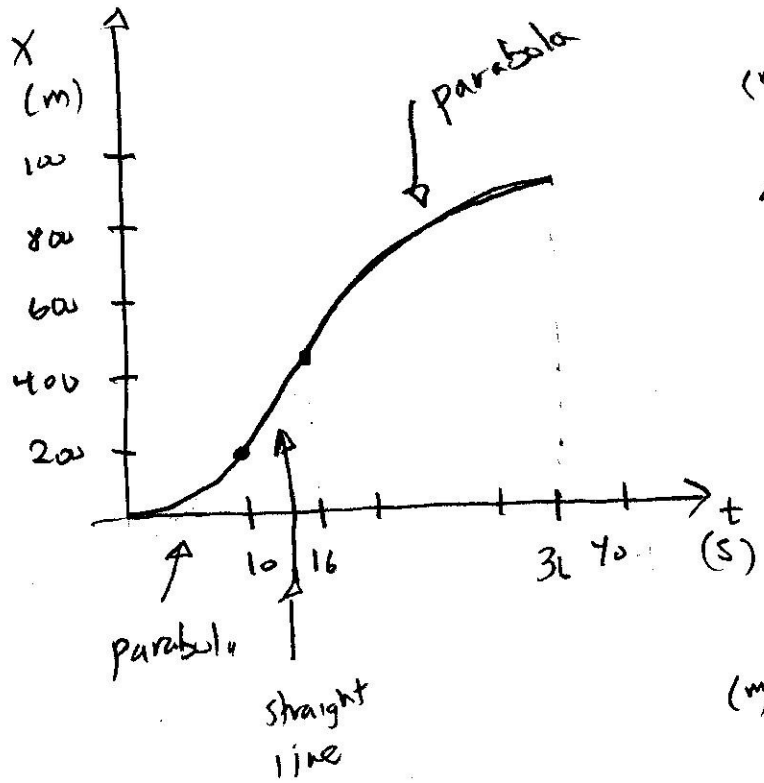
↑ because after 10 seconds with $a = 4$ m/s^2 car is going 40 m/s

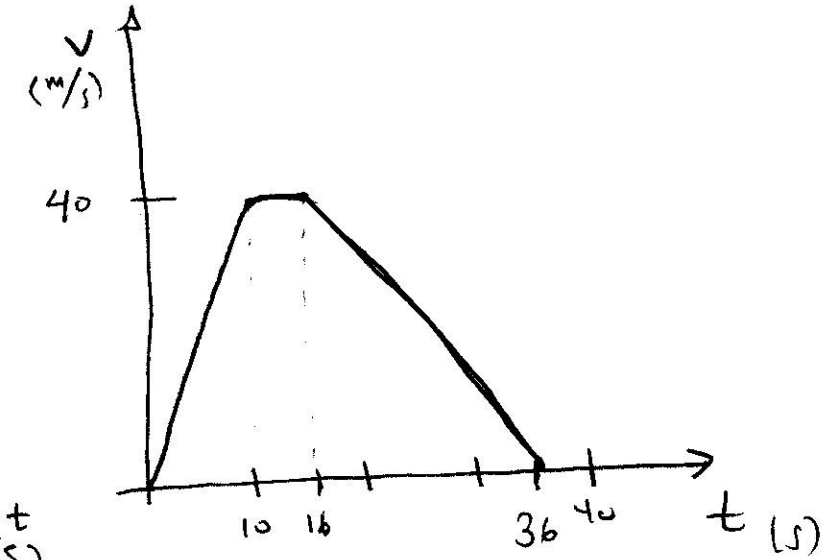
Final period $v^2 - v_0^2 = 2a(x - x_0)$

$0^2 - 40^2 = 2(-2)(x - 440)$

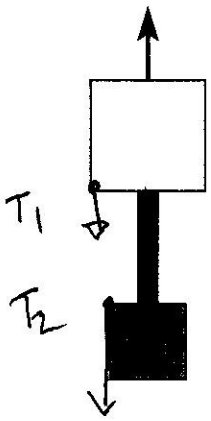
$x - 440 = 400 \qquad x = 840$ m

It takes 20 seconds to slow to 0 m/s at $a = -2$ m/s^2





[3.] An upwards force of 250 N acts on object A (which has m_A=4 kg). See figure. Object A is connected by a heavy rope (which has mass m_{rope}=2 kg) to object B (which has m_B=7 kg). Gravity acts downward on both objects, and the rope. Compute the acceleration of the system and the tension at the top and bottom of the rope.



F = 250 N

m_A = 4 kg

m_{rope} = 2 kg

m_B = 7 kg

A: $250 - T_1 - 4(9.8) = 4a$

rope: $T_1 - T_2 - 2(9.8) = 2a$

B: $T_2 - 7(9.8) = 7a$

all accelerations equal!

Adding:

$250 - 13(9.8) = 13a$

$\rightarrow a = 9.431\ m/s^2$

plugging in B eqn $T_2 = 134.6$ N

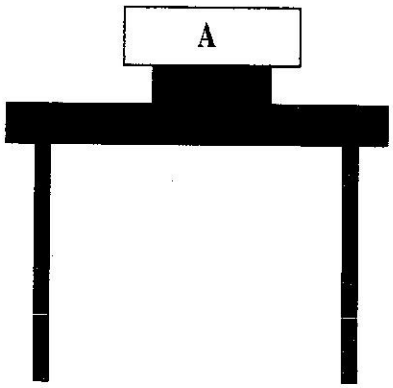
plugging in A eqn $T_1 = 173.1$ N

check in rope eqn

$173.1 - 134.6 - 2(9.8) \stackrel{?}{=} 2(9.431)$

$\surd\surd$

[4.] Refer to the picture below of two books sitting on a table that is sitting on the floor. (a) Make a force diagram of each of the three objects: books A,B, and the table. The masses of the books are 1.8 kg and 0.6 kg for A and B, respectively, and the mass of the table is 30 kg. (b) Identify all 3rd law pairs of forces in your force diagrams. (c) Determine values of all the forces acting on the books and table. (d) If the books and table are sliding horizontally across the room at the same constant speed, how would your force diagrams change? Show precisely how it would change or explain why it would not. (e) Now imagine the table is in an elevator accelerating upward at 2 m/s^2. Determine values for the forces acting on the books and table in this new situation.



c: $F_{B\text{ on }A} + W_A = 0$ $\quad F_{A\text{ on }B} = -17.64\ N$

$F_{B\text{ on }A} = -W_A = +1.8(9.8) = 17.64\ N$ ⇑

$F_{\text{Table on }B} + W_B + F_{A\text{ on }B} = 0$

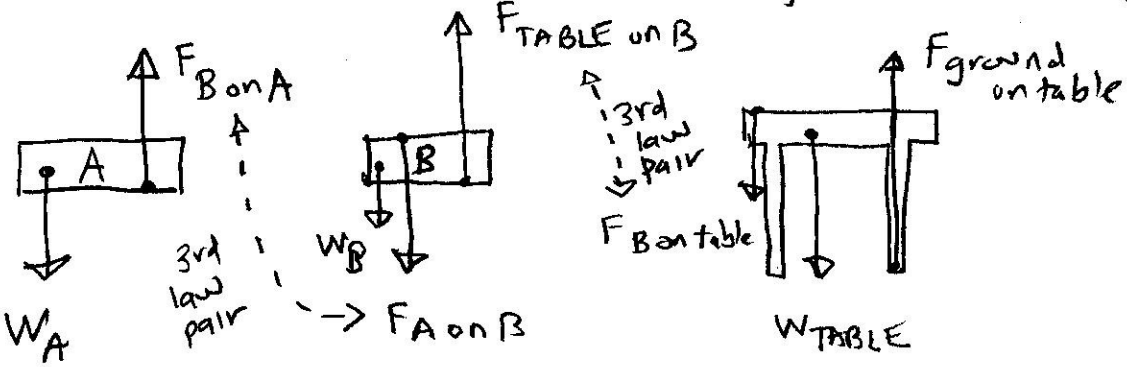
$F_{\text{table on }B} = 5.88 + 17.64 = 23.52\ N$

$F_{B\text{ on table}} = -23.52\ N$

$F_{\text{ground on table}} + W_{\text{table}} + F_{B\text{ on table}} = 0$

$F_{\text{ground on table}} = 30(9.8) + 23.52 = 317.52\ N$

a,b:



d) Eqns above use $\vec{F} = m\vec{a}$ where $\vec{a} = 0$.

If $\vec{v}$ = constant $\vec{a}$ is still zero and equations do not change

e) Redo calculations with ma and $a = 2$ on right side of eqn

For example $F_{B\text{ on }A} + W_A = m_A a$

$F_{B\text{ on }A} = (1.8)(9.8) + (1.8)2 = 21.24\ N$

etc.