October 19, 2011.

Name (please print):
Signature:
Student Number (optional):

PHYS 1420 6.0
Test 1A

1. (6 marks)

The position of a particle moving along an x axis is given by $x = 2.0t^3 - 8.0t$, where t is in seconds and x is in meters.

a. Determine the instantaneous velocity and the instantaneous acceleration at t = 1.0 s.

$$v = \frac{dx}{dt} = 6.0t^2 - 8.0$$

$$v(t = 1.0\,s) = (6.0)(1.0)^2 - 8.0 = -2.0\ m/s$$

$$a = \frac{dv}{dt} = 12.0t$$

$$a(t = 1.0\,s) = (12.0)(1.0) = 12.0\ m/s^2$$

b. At t = 1.0 s, is the particle moving in the positive or negative x-direction? Explain.

IN THE NEGATIVE X-DIRECTION BECAUSE v IS NEGATIVE

c. Determine the average acceleration between t = 1.0 s and t = 2.0 s.

$$\bar{a} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{[(6.0)(2.0)^2 - 8.0] - [(6.0)(1.0)^2 - 8.0]}{2.0 - 1.0}$$

$$\bar{a} = 18\ m/s^2$$

2. (6 marks).

A package is dropped from a helicopter that is descending at a constant speed $v_0 = 4.0$ m/s.

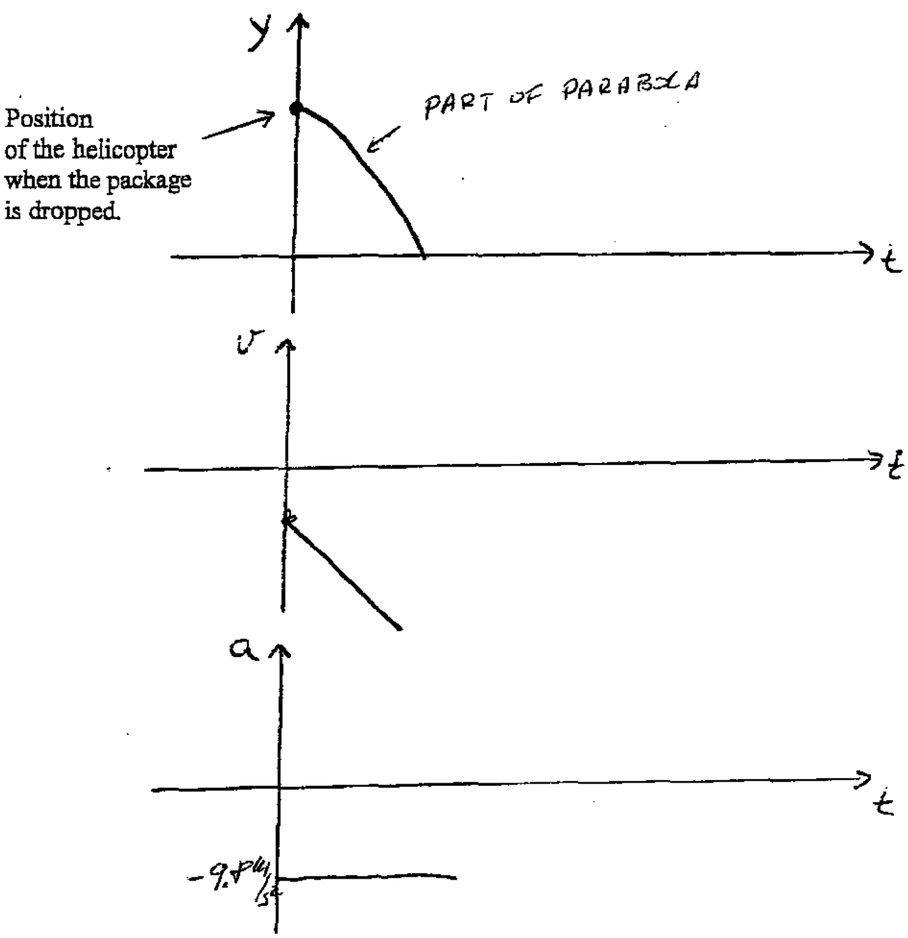
a. After t = 2.0 s have elapsed, what is the speed of the package and its distance from the helicopter?

$$v = v_0 + at = \left|(4.0\ \text{m/s}) + (-9.8\ \text{m/s}^2)(2.0\ \text{s})\right| = 23.6\ \text{m/s}$$

$$\text{DISTANCE} = \left|\left(v_0 t + \tfrac{1}{2}at^2\right) - v_0 t\right| = \left|\tfrac{1}{2}at^2\right| = \left|\tfrac{1}{2}(-9.8\ \text{m/s}^2)(2.0\ \text{s})^2\right|$$

$$\text{DISTANCE} = 19.6\ \text{m}$$

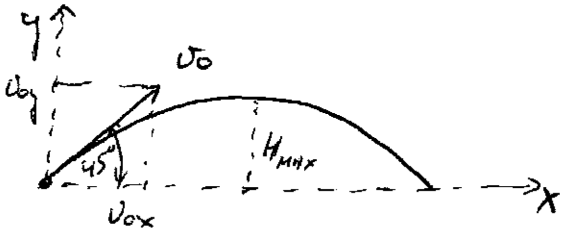
b. Sketch the time dependence of the package's height above the ground, its velocity and acceleration after it is released from the helicopter.



3. (6 marks).

Chinook salmon is able to move upstream faster by jumping out of water periodically. Suppose a salmon swimming in still water jumps out of water with speed 6.26 m/s at an angle of 45.0^0, travels through the air a horizontal distance L before returning to the water.

a. Determine the distance L, the time the salmon is in the air in a single jump and the maximum height above the water reached by the salmon?



$v_{0x} = (6.26\ m/s)(\cos 45°) = 4.43\ m/s$

$v_{0y} = (6.26\ m/s)(\sin 45°) = 4.43\ m/s$

AT THE MAXIMUM HEIGHT $v_y = 0$

$v_y = v_{0y} + a_y t = (4.43\ m/s) + (-9.8\ m/s^2)\, t_{max}$

$t_{max} = 0.452\ s$

$t = 2\, t_{max} = 0.904 s.$

$L = (v_{0x})(2\, t_{max}) = (4.43\ m/s)(2)(0.452 s) = 4.00 m.$

$H_{MAX} = v_{0y} t_{max} + \frac{1}{2} a_y t_{max}^2 = (4.43\ m/s)(0.452 s) + \frac{1}{2}(-9.8\ m/s^2)(0.452 s)^2$

$H_{max} = 1.00 m.$

b. At what point during the jump is salmon's speed smallest? Explain.

AT THE MAXIMUM HEIGHT WHERE $v_y = 0$

AT THE MAXIMUM HEIGHT $v = v_{0x}$, $v_y = 0$

AT ANY OTHER POINT $v_y \neq 0$

4. (8 marks)

Answer the following four multiple-choice questions.

a. Which of the following statements regarding the diffusion process is true?

1. All molecules diffuse the same distance called the root-mean-square distance.
2. All molecules diffuse in the same direction.
3. Approximately 2/3 of molecules travel a distance larger than the root-mean-square distance.
4. Some molecules travel a distance 10 times larger than other molecules.
5. The diffusion of molecules is faster in liquids of high viscosity.

b. If Earth's mass and radius both suddenly doubled, what would be the new value of the gravitational acceleration near Earth's surface?

1. 19.6 m/s^2
2. 9.80 m/s^2
3. 4.90 m/s^2
4. 2.45 m/s^2
5. 1.23 m/s^2
6. 1.0 m/s^2

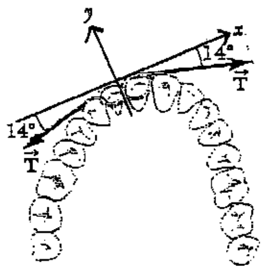
$g = G\frac{M_E}{R_E^2}$, $G\frac{(2M_E)}{(2R_E)^2} = \frac{1}{2} G \frac{M_E}{R_E^2} = \frac{1}{2}(9.8\,m/s^2) = 4.90\,m/s^2$

c. A certain orthodontist uses a wire brace to align patient's teeth. The tension T = 20.0N. The net force **F** exerted by the wire on the teeth (written in terms of unit vectors **i** and **j**) is

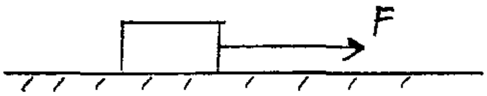
1. **F** = (19.4 N)**i** + (9.68 N)**j**
2. **F** = (38.8 N)**i** – (4.84 N)**j**
3. **F** = -(19.4 N)**i**
4. **F** = –(9.68 N)**j**
5. **F** = (9.68 N)**j**

$\Sigma T_x = 0$

$\Sigma T_y = -2(T)\sin 14° = -2(20N)\sin 14° = -9.68N$



d. A horizontal force F = 18.0 N is applied to a block of mass m = 10.0kg, as shown below. Coefficients of friction, static and kinetic, between the floor and the block are 0.15 and 0.12, respectively. The following statement regarding the block is true.



1. The force of friction acting on the block is 11.8 N
2. The force of friction acting on the block is 14.7 N
3. The force of friction acting o the block is 2.90 N
4. The force of friction acting on the block is zero because the block is stationary.
5. The block is moving and the force of friction acting on the block is 14.7 N.

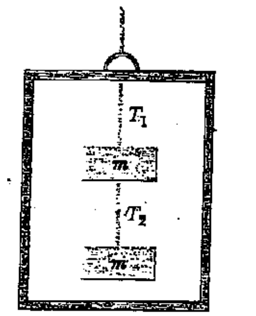
THE BLOCK MOVES BECAUSE $F = 18.0N > f_{S\,MAX} = \mu_s mg = (0.15)(10.0kg)(9.80m/s^2) = 14.7N$

THUS, KINETIC FORCE OF FRICTION

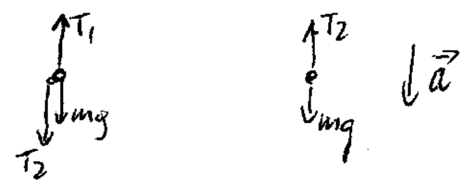
$f_k = \mu_k N = \mu_k mg = (0.12)(10.0kg)(9.80m/s^2) = 11.8N$

5. (6 marks)

Two blocks each of mass m= 4.0 kg are fastened to the top of an elevator, as shown below. The elevator has a downward acceleration $a = 2.2\ m/s^2$.



a. Draw a free-body force diagram for each mass. Which forces included on your diagrams form an action-reaction pair of forces?



NONE OF THE FORCES ABOVE FORM AN ACTION - REACTION PAIR OF FORCES

b. Find the tensions T_1 and T_2 in the upper and lower strings.

TAKING THE y-AXIS DOWNWARD AND USING NEWTON'S II LAW

$$T_2 + mg - T_1 = ma$$

$$mg - T_2 = ma$$

ADDING BOTH EQUATIONS

$$2mg - T_1 = 2ma$$

$$T_1 = 2m(g-a) = 2(4.0\,kg)(9.80\ m/s^2 - 2.2\ m/s^2) = \underline{61N}.$$

$$T_2 = T_1 + ma - mg = T_1 + m(a-g) = 61N + (4.0\,kg)(2.2\ m/s^2 - 9.80\ m/s^2)$$

$$\underline{T_2 = 31N}.$$

$$\bar{v} = \frac{\Delta x}{\Delta t},\quad v = \frac{dx}{dt},\quad \bar{a} = \frac{\Delta v}{\Delta t},\quad a = \frac{dv}{dt}$$

$$v = v_0 + at,\quad \Delta x = v_0 t + \frac{1}{2}at^2,\quad v^2 = v_0^2 + 2a\Delta x$$

$$F = G\frac{Mm}{r^2},\quad g = G\frac{M_E}{R_E^2} = 9.8\ m/s^2,\quad F_g = mg$$

$$\sum \vec{F} = m\vec{a},\quad X_{rms} = \sqrt{2Dt},\quad f = \mu N$$

$$ax^2 + bx + c = 0,\quad x_{1,2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$\frac{dx^n}{dx} = nx^{n-1},\quad \frac{d(\sin x)}{dx} = \cos x,\quad \frac{d(\cos x)}{dx} = -\sin x$$