Your name:	
Your TA:	
Your section Day/Time:	

PHY 101 In-class Exam I

Wednesday, September 27, 2:15-3:35 PM

Please be sure to show your work where it is requested. If no work is shown where it is requested, you will not receive any points. Also, partial credit will be given where appropriate, so *show me your physics thoughts*

Please answer the following multiple choice questions. Circle only one answer per question.

(1) Which of the following is a scientific hypothesis?
A. Matter is filled with undetectable particles.
B. The Moon is made of green cheese.
C. There are things we will never know about.
D. There are parts of the universe that will never be found by human beings.

(2) To be dimensionally consistent, velocity [m/s], acceleration [m/s^2] and time [s] must be related as follows:
A. velocity = acceleration $\times$ time
B. velocity = acceleration $\times$ time^2
C. velocity = acceleration^2 $\times$ time
D. velocity = acceleration^2 $\times$ time^2

(3) By what factor does the volume of a cube increase if the length of all of the edges are tripled?
A. 6
B. 9
C. 3
D. 27

(4) One angstrom = 10^{-10} m and one fermi = 10^{-15} m, what is the relationship between these units?
A. 1 angstrom = 10^5 fermi
B. 1 angstrom = 10^{-5} fermi
C. 1 angstrom = 10^{25} fermi
D. 1 angstrom = 10^{-25} fermi

(5) On a graph of x versus time, the slope represents
A. the change in the x part of the velocity, Δv_x
B. the x part of the displacement, Δx
C. the x part of the velocity, v_x
D. the x part of the acceleration, a_x

(6) When a rock is thrown straight upwards, at the exact top of its path, its
A. velocity is zero and its acceleration is zero.

B. velocity is 9.8 m/s and its acceleration is zero.
C. velocity is zero and the magnitude of its acceleration is 9.8 m/s^2.
D. velocity is 9.8 m/s and its acceleration is 9.8 m/s^2.

(7) When an object is released from rest and falls (where there is no air resistance), which of the following is true?
A. The acceleration is constant.
B. The velocity is constant.
C. Neither the acceleration nor velocity is constant.
D. Both the acceleration and velocity are constant.

(8) A heavy object and a light object are dropped at the same time from rest in a vacuum. The heavier object reaches the ground
A. sooner than the lighter object.
B. later than the lighter object.
C. at the same time as the lighter object.
D. almost immediately.

(9) A space probe leaves the solar system to explore interstellar space. Once it is far from any stars, when must it fire its rocket engines?
A. All the time in order to keep it moving.
B. Only when it wants to speed up.
C. When it wants to speed up, slow down, or turn.
D. Only when it wants to slow down.

(10) An apple has a mass of 0.5 kg. When the apple is in free-fall (neglecting air resistance and near the surface of the Earth), the magnitude of the total force on it is
A. 49.0 N.
B. 4.9 N.
C. 0.49 N.
D. 0 N.

(11) Which has no acceleration? An object
A. at rest.
B. moving at constant velocity.
C. in translational equilibrium.
D. all of these.

(12) Two balls, identical except for color, are projected horizontally from the roof of a tall building at the same instant. The initial speed of the red ball is twice the initial speed of the blue ball. Ignoring air resistance,
A. the red ball reaches the ground first.
B. the blue ball reaches the ground first.
C. both balls land at the same instant with different speeds.
D. both balls land at the same instant with the same speed.

Now respond to the following short answer questions. Please answer THREE out of FOUR for questions (13)-(16). CLEARLY indicate which ones you would like to be graded.
(13) Do you remember when Professor Schwarz "blasted" into class in a rocket car? Describe the motion of the car and discuss what physics concept/principle/law the rocket car was demonstrating.

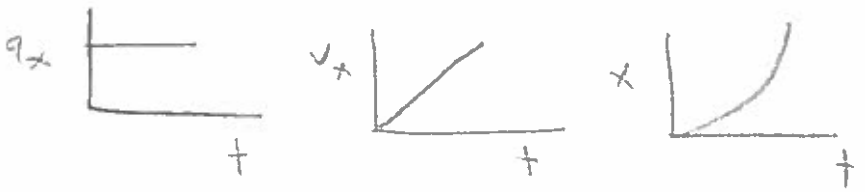
Newton's Third Law

(14) If you want throw an object so that it lands the furthest possible distance from you, what angle (with respect to the ground) should you launch the object? What equation did you use to justify your answer? Where does this equation come from?

45° ; $R = \frac{v_i^2 \sin(2\theta_i)}{g}$

The range equation comes from the equations for $\Delta y(t)$ and $\Delta x(t)$ for constant acceleration

(15) Think back to your first lab with cart, the track, and the motion detector. A cart is moving eastward with a constant acceleration along a frictionless track during a time interval of 10 seconds. *Sketch* the displacement, the velocity, and the acceleration of the train as a function of Δt. Use three separate graphs and carefully label which one is which.



(16) Discuss Newton's First Law and Newton's Second Law and how they each impact your own life.

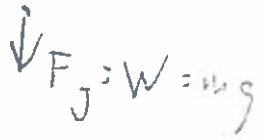
1st law: object at rest stays at rest and an object in motion maintains its speed and direction if and only if the net force on it is 0 → seat belts

2nd law: $\sum F_x = ma_x$; $\sum F_y = ma_y$ how objects fall due to gravity

Now answer THREE of the following FOUR quantitative questions. Please clearly indicate which ones you would like to be graded and you can use $g = 10$ m/s^2.

(17) A 1 kg stick of dynamite dropped down a mine shaft takes 10 seconds to reach the bottom floor of a mine shaft. Neglect air resistance.

(a) Draw the force(s) on the stick of dynamite as it falls down the mine shaft.



(b) How deep is the mine shaft?

$y_f = y_i - \frac{1}{2} g (\Delta t)^2 = -\frac{1}{2} 10 m/s^2 (10 s)^2 = -5 (100 m) = -500$

$v_{f_y} = v_{i_y} - g(\Delta t) = -10 m/s^2 (10 s) = -100 m/s$

(c) With what speed does the dynamite stick hit the bottom floor of the mine shaft?

(d) If we were to include air resistance describe how the value obtained in (c) would or would not change.

It would change.

(18) The orange jewelweed has seed pods that explode when lightly touched, launching the seeds as projectiles to disperse them. Suppose a seed is launched horizontally at a speed of 4 m/s from a height of 20 m. (It's the world's tallest orange jewelweed plant.) Assume air resistance is negligible

and that the seed follows a clear path to the ground.
(a) What equations describe the motion of the seed in terms of position as a function of time and velocity as a function of time?

$\Delta x = v_{ix}\Delta t + \frac{1}{2}a_x(\Delta t)^2$

$\Delta y = v_{iy}\Delta t + \frac{1}{2}a_y(\Delta t)^2$

$\Delta v_y = a_y \Delta t$

$\Delta v_x = a_x \Delta t$

$a_x = 0$

$a_y = -g$

(b) How long does it take for the seed to hit the ground?

$y_f = 0$, $y_i = 20\,m$ $\quad v_{iy} = 0$; $v_{ix} = 4\,m/s$

$0\,m = 20\,m - \frac{1}{2}(10\,m/s^2)(\Delta t)^2$

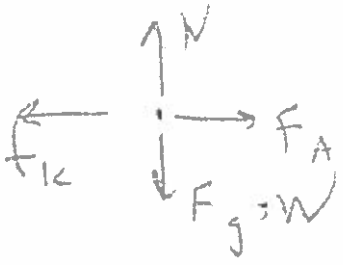
$-20\,m = -\frac{1}{2}(10\,m/s^2)(\Delta t)^2 \rightarrow \left(\frac{40\,s^2}{10}\right)^{\frac{1}{2}} = \Delta t$

$\rightarrow \Delta t = 2\,s$

(c) What horizontal distance from the seed pod does the seed hit the ground?

$\Delta x = (4\,m/s)(2\,s) = 8\,m$

(19) A 4 kg box sits on the floor. The box is then being pushed along the floor at constant speed with force 10 N.
(a) Draw the forces on the box as it is being pushed along the floor.



(b) Write down Newton's Second Law (in each direction) for the box as it is being pushed along the floor.

$\Sigma F_x = ma_x$ $\quad a_x = 0 = a$

$\Sigma F_y = ma_y$ $\quad a_y = 0 = a$ → along floor

constant speed

(c) What is the coefficient of kinetic friction between the box and the floor?

$F_A = 10\ N$

$m = 4\ kg$

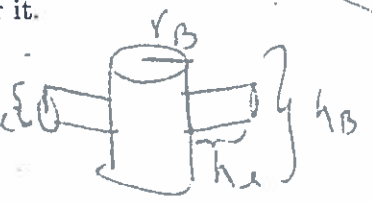
$N - mg = 0 \rightarrow \quad N = mg$

$F_A - f_K = 0 \rightarrow \quad F_A = f_K = \mu_k N = \mu_k mg$

$\frac{F_A}{mg} = \mu_k = \frac{10\ N}{(4\ kg)(10\ m/s^2)} = .25 = \frac{1}{4}$

(20) In class we estimated the number of cells in the human body. We assumed the typical human body to be the shape of one big cylinder with a height of 2 m and a radius of 0.1 m. We assumed the shape of a typical cell to be spherical with a radius of 5 microns. Thinking back to our practice test, how would our estimate for the number of cells in the human body change if we were to include the arms explicitly as two smaller cylinders each with a height of 1 m and a radius of 5 cm? Get as close as you can to a number (of cells) but don't sweat over it.

$1\ \mu m = 10^{-6}$



$N_{cells} = \frac{V_{body}}{V_{cell}} = \frac{\pi r_B^2 h_B + 2\pi r_L^2 h_L}{\frac{4}{3}\pi r_c^3}$

r_c = radius of cell

$N_{cells} = \frac{3}{4}\left[\frac{r_B^2 h_B + 2r_L^2 h_L}{r_c^3}\right]$

$= \frac{3}{4}\left[\frac{(.1\ m)^2(2\ m) + 2(.05\ m)^2(1\ m)}{(5\times10^{-6}\ m)^3}\right] = \frac{3}{4}\left[\frac{.02\ m^3 + .005\ m^3}{125\times10^{-18}\ m^3}\right]$

$= \frac{3}{4}\left[\frac{.025\ m^3}{1.25\times10^{-16}\ m^3}\right]$

$= \frac{3}{4}\left[\frac{2.5\times10^{-2}}{1.25\times10^{-16}}\right] = \frac{3}{4}\left[\frac{2.5}{1.25}\times10^{14}\right] = \frac{7.5}{5}\times10^{14} = 1.5\times10^{14}$