Name: _____

You may answer the questions in the space provided here, or if you prefer, on your own notebook paper.

Short Problems

$$
\begin{aligned}
v_f &= v_i + at \\
x_f &= x_i + \frac{1}{2}(v_i + v_f)\,t \\
x_f &= x_i + v_i t + \frac{1}{2}at^2 \\
v_f^2 &= v_i^2 + 2a\,(x_f - x_i) \\
\sum F &= ma
\end{aligned}
$$

Multiple choice

1. [1 point] Which of the following is *not* in the metric system?

   ◯ Liters ◯ Inches ◯ Seconds ◯ Kelvin

2. [1 point] How many centimeters are in one meter?

   ◯ 0.01 ◯ 0.1 ◯ 10 ◯ 100 ◯ 1000

3. [1 point] Which of the following is not a vector?

   ◯ Temperature ◯ Velocity ◯ $300\hat{i} + 20\hat{j}$ ◯ Gravitational force

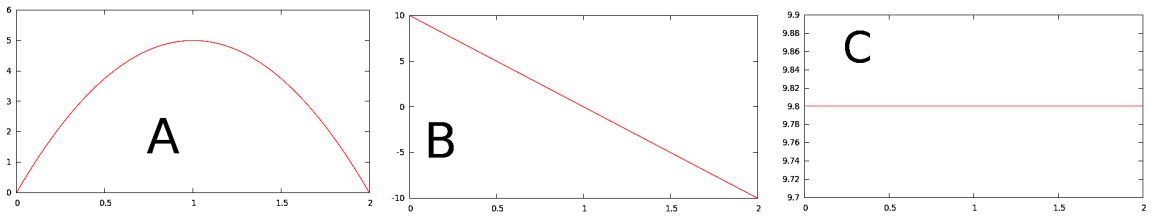
4. [1 point] Suppose I were driving on a round trip to Wilmington Delaware and back. I travel 30 miles to Wilmington in 0.5 hours, and then I travel back in 1 hour (bad traffic). Assume that I travel on i95, which unlike I-95, travels in a straight line from Philadelphia to Wilmington. What is my average **speed?**

   ◯ -30 miles per hour ◯ 0 miles per hour ◯ 30 miles per hour ◯ 40

Please go on to the next page...

miles per hour

5. 1 point Which of the following correctly identifies the following graphs of a balling being thrown directly upwards:



◯ A: Position; B: Velocity; C: Acceleration ◯ A: Velocity; B: Position; C: Acceleration
◯ A: Position; B: Acceleration; C: Velocity ◯ A: Acceleration; B: Velocity; C: Position

6. 1 point Which of Newton's Laws discuss equal and opposite forces?

◯ Newton's First Law ◯ Newton's Third Law ◯ Newton's Second Law

7. 1 point If the net forces acting on an object is equal to zero, then

◯ The object is at rest ◯ There is no friction ◯ There is no acceleration

8. 1 point When we talk about friction forces, we know that

◯ $\mu_s < \mu_k$ ◯ $\mu_s = \mu_k$ ◯ $\mu_s > \mu_k$

9. 1 point A fictitious force is a force which

◯ Appears to act when $\sum F = 0$. ◯ Can't be measured ◯ Is seen in inertial frames

10. 1 point In an inertial frame of reference,

◯ there are fictitious force ◯ $\sum F = 0$ implies no acceleration ◯ acceleration is zero

11. [1 point] Normal forces

◯ act perpendicular to the surface of contact ◯ act in the same direction as gravity

12. [1 point] Suppose you are standing on a scale to weight yourself on an elevator accelerating upwards. A scale measures your normal force. You will appear to

◯ weigh less ◯ weigh more ◯ weigh the same

13. [1 point] On and off ramps for major highways are banked at an angle. This is to counterbalance

◯ Normal Force ◯ Gravitational Force ◯ Centripetal Force

14. [1 point] Parachutes are used in order for sky jumpers to have a slower

◯ Terminal Velocity ◯ Drag Coefficient ◯ Inertial Frame

Conversions

1. [5 points] Water is being pumped out of a pool at **32 liters per second**. How many **gallons per minute** will this be?

   1 L = 0.2642 gal

   How many **gallons per hour** will this be?

Bonus question: If we originally have **73239 gallons** of water, in how many seconds will the water be gone?

2. [1 point] How many milligrams are in one kilogram?

3. [1 point] How many meters are in one 35.25 kilometers?

4. [5 points] It takes two hours to fill a 252.0 gallon gasoline tank. What is the rate it is being filled in cubic meters per seconds? (Given: 1 $m^3 = 264.172$ gal).

Motion in One Dimension

Kinematic Equations for Motion of a Particle Under Constant Acceleration

$$\begin{aligned} v_f &= v_i + a_x t \\ x_f &= x_i + \frac{1}{2}(v_i + v_f)t \\ x_f &= x_i + v_i t + \frac{1}{2}at^2 \\ v_f^2 &= v_i^2 + 2a(x_f - x_i) \end{aligned}$$

Bonus: Equation for particle with no acceleration but constant velocity

$$x_f = x_i + vt \tag{0.1}$$

Extra equation:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

1. [20 points] Two race cars are racing towards the finish line along a straight track. Red car is traveling at a constant velocity of 125 m/s. Blue car is ahead of Red car, but is having motor trouble and is slowing down. When the cars pass each other, Blue car has a velocity of 110 m/s and is slowing at a rate of -2 m/s^2. The Red car makes it to the finish line in 10 seconds. How long will it take for the Blue car to make it to the finish line?

2. [3 points] Sketch the position, velocity, and acceleration graph (verses time) for the Red car in the previous problem.

3. [3 points] Sketch the position, velocity, and acceleration graph (verses time) for the Blue car in the previous problem.

Motion in Two Dimensions

The kinematic equations from the previous page will be useful on some of these problems.

1. [10 points] A ship is traveling in a calm sea 23 miles per hour at 17 ° North of East with a constant velocity when it suddenly hits the Gulf Stream which is an area in the ocean where the water flows rapidly in one direction. The stream is directed Northward at 5.6 miles per hour. Ignoring drag, what is the new velocity of the ship? Please put your answer in vector notation (example: $v = 100$ mph $\hat{i} + 200$ mph $\hat{j}$, 223.6 mph, 63° North of East.).

2. [10 points] Regarding the previous problem, the ship wants to get back on course with the same speed as before it hit the Gulf Stream. What change in speed should the captain order? Hint: What is the vector difference between its original speed and its speed after passing into the Gulf Stream? Your can answer this in $\hat{i} + \hat{j}$ notation.

3. [10 points] NASA has lost contact with a flying drone. The drone is flying along a straight line at 113.101 meters per second, holding at a constant altitude of 6096 meters. NASA positions a cannon to shoot it down. The drone passes over the cannon at the same instance the cannon is fired. If the cannon's projectile hits the drone 30 seconds later, how far has the drone traveled in the horizontal direction?

4. [25 points] Find the velocity and angle combination for the cannon that would enable the projectile from the previous problem to hit the flying drone? Use all of the information from the previous problem and the kinematic equations. The acceleration due to gravity is $-9.8m/s^2$. Ignore air drag and assume that the projectile starts at position $x_i = 0$, $y_i = 0$.

Free Body Diagrams

For each of the objects below, draw corresponding free body diagrams, label all forces, and write the corresponding net force equation(s).

1. [5 points] A ball resting on a table.

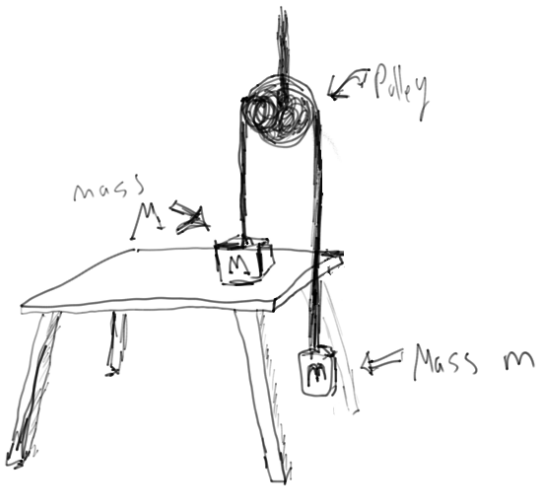
2. [5 points] A hockey puck is struck with a force of one Newton at 60 degrees from the x axis and two Newtons at 20 degrees from the x axis. Draw graphically (but don't find numerically) the net resulting force. You can guess what the angles 60 and 20 would be, no need for a protractor. Assume no friction.

3. [10 points] A ball of mass m on a table is connected by string to a ball of mass M hanging on the side of the table, such that the friction between the ball on the table and the table is enough to keep the system in equilibrium and at rest.

Problems

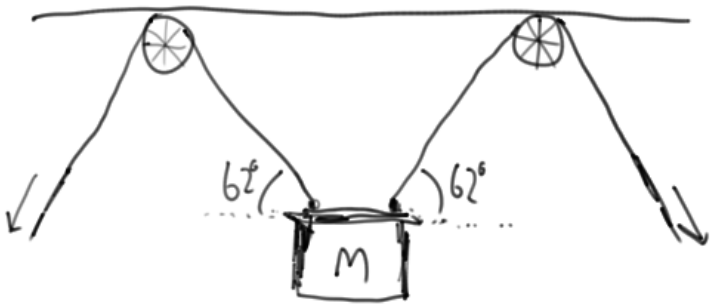
For each problem, draw corresponding free body diagrams, label all forces, and write the corresponding net force equation(s) to solve for stated unknown quantity.

1. [15 points] A weight of mass M is resting on a table and attached, via pulley, to another weight of mass m ($M > m$). The entire system is at rest. What is the normal force, as



a function of M, m, and g?

2. [15 points] A load of mass 325 kg is being lifted up by two ropes looped through a pulley. The ropes each have a tension of 2850 N, and they attach to the load at an angle of 62° (see drawing). Find the net acceleration of the load.



3. [15 points] Imagine a puck on a table with friction. The puck is attached to the center of the table by a string which is 0.5 m long. The puck has a mass of 0.2 kg and is set in motion at an initial velocity of 10 m/s, thus setting it in a circular motion. The centripetal force will result in a tension in the string. Furthermore, the table has a coefficient of kinetic friction $\mu_k = 0.2$. What is the initial tension in the string and what is the rate at which the puck will deaccelerate due to friction as it loops around the circular path? Recall from lecture that the centripetal force is

$$F_c = \frac{mv^2}{R}$$