Test 1 will include material from chapters 1-7. You should review your homework problems, quizzes, recitation problems, etc. An incomplete and brief summary of the topics and concepts this includes is given by:

**Test 1 Summary of Material Covered:**

**Kinematics (motion)**

1) kinematics in one dimension
   a. one object with constant acceleration
   b. $x(t)$ vs. $t$, $v(t)$ vs. $t$, $a(t)$ vs. $t$ graph problems
   c. two objects with constant velocity
   d. use calculus to derive motion equations, derivatives and integrals

2) kinematics in two dimensions
   a. one object projectile motion (constant acceleration in one dimension and zero acceleration in the other dimension)
   b. one object centripetal acceleration

**Forces (cause of motion)**

3) one object linear motion with and without friction
   a. using Newton’s 1st & 3rd laws and the principle of superposition to add find many forces and add to get $F_{\text{net}}$.

   ![Composite View](image)

   - Composite View
   - Total View

   b. using Newton’s 2nd law to relate $F_{\text{net}}$ to $a_{\text{net}}$: force information to kinematics information (motion)

   c. some common systems
      1) inclined plane
      2) elevator
      3) unstretching, massless rope
      4) mass suspended by pulley
      5) mass on spring
4) one object circular motion
   a. constructing a free body diagram to find the sum of the component forces that give \( F_{\text{net}} = F_{\text{net, cent}} \). Remember, the centripetal force is not a real force but a description of how all the real, physical forces combine to cause circular motion.
   b. \( F_{\text{net, cent}} = \frac{mv^2}{r} \)
   c. note: be able to convert revolutions per minute to speed
5) two objects connected
   a. share common \( a_{\text{net}} \) magnitude: ex. \( \frac{|F_{\text{net}, A}|}{m_A} = \frac{|F_{\text{net}, B}|}{m_B} \)
   b. common situations
      1) two masses connected by rope and pulley
      2) two masses on surface touching
6) two objects forces on one another
   a. gravity between two objects, find \( F_G \)
      1) find \( g_{\text{surface}} \) for any planet given M and R
      2) relate \( F_G \) to circular orbit centripetal acceleration on smaller mass orbiting larger mass

Work (connecting forces to energy)
7) calculating work depending on the complexity of the situation
   a. one dimension, constant force: \( W = \pm Fd \)
   b. two dimensions, constant force: \( W = \vec{F} \cdot \vec{d} \)
   c. one dimension, position dependent force: \( W = \int_{x_i}^{x_f} F(x)dx \)
8) relating kinematics information to force information using \( W_{\text{net}} = \Delta K \)
9) some special situations
   a. pulling wagons
   b. inclined planes
   c. springs
Test 1 Practice Problems:

Kinematics (motion)
1) kinematics in one dimension
   a. one object with constant acceleration

   An object moving +30 m/s forward brakes with an acceleration of -5 m/s² for 10 seconds. What is its velocity and where is it located in relation to the position where braking first occurred?

   b. x(t) vs. t, v(t) vs. t, a(t) vs. t graph problems

   An object initially at rest at the origin accelerates for 2 seconds at +4 m/s², and then accelerates at -12 m/s² for 1.5 seconds. Construct an x(t) vs. t graph and determine the final position of the object.

   c. two objects with constant velocity

   Two objects are initially 50 m apart. Object A is moving to the right with a constant velocity of 22 m/s. Object B is moving with a constant speed of 17 m/s. Find the position and time of collision if object B is moving to the left and the position and time of collision if object B is moving to the right.

   d. use calculus to derive motion equations, derivatives and integrals

   An object is initially located at x₀=5 m. Given the velocity equation v(t)=4t⁴, find equations to describe the position and acceleration of the object.

2) kinematics in two dimensions
   a. one object projectile motion (constant acceleration in one dimension and zero acceleration in the other dimension)

   A basketball is thrown from an initial height of 2 m with a velocity of 15 m/s at angle of 78° above the horizon. The ball rises into the air in a parabolic arc, reaches the top of its arc, then begins to fall downward. It strikes the rim of the basket 3.2 m high. How much time passes from the ball being thrown to when it struck the rim?

   b. one object centripetal acceleration

   A speck of dust lies on the edge of a compact disc 10 cm in diameter. If the disc spins at 200 revolutions per minute, what is the magnitude of the centripetal acceleration of the dust speck?
Forces (cause of motion)
3) one object linear motion with and without friction
   a. using Newton’s 1\textsuperscript{st} & 3\textsuperscript{rd} laws and the principle of superposition to add find many forces and add to get $F_{\text{net}}$.

\begin{center}
\begin{tikzpicture}
\draw[-latex, thick] (0,0) -- (2,0) node[midway, above] {$F_{\text{net}}$};
\draw [-latex, thick] (0,0) -- (-2,0) node[midway, above] {$F_1$};
\draw [-latex, thick] (0,0) -- (0,2) node[midway, right] {$F_2$};
\draw [-latex, thick] (0,0) -- (0,-2) node[midway, right] {$F_3$};
\draw [-latex, thick] (0,0) -- (2,2) node[midway, right] {$F_4$};
\end{tikzpicture}
\end{center}

b. using Newton’s 2\textsuperscript{nd} law to relate $F_{\text{net}}$ to $a_{\text{net}}$: force information to kinematics information (motion)
c. some common systems
   1) inclined plane

   \textit{How long does it take a 5 kg object to slide 3 meters down a 45° ramp starting from rest with a coefficient of friction of 0.1?}

   2) elevator

   \textit{What will a weight scale read in an elevator moving at a constant 4 m/s upward? If this upward moving elevator takes 3 s to come to a stop during a period of constant acceleration, what will the scale read as it comes to a stop?}

   3) unstretching, massless rope

   \textit{An emergency helicopter is accelerating upward at 3 m/s\textsuperscript{2}. A cord attached to the helicopter carries a rescue worker and two injured hikers in a basket with a total mass of 360 kg. What is the tension in the cord?}
4) mass suspended by pulleys

In the following compound pulley system, a 7 kg mass is attached to the lower pulley by cord 2 while the upper compound pulley is attached to the ceiling by cord 3. A person holds the end of cord 1. Find the tension force in each of the three cords of the system if the mass is at rest.

5) mass on spring

A mass moves in a horizontal circle on a frictionless surface at a constant speed, \( v \). It is attached to a spring with spring constant \( k_s \) and equilibrium distance \( d \) that is displaced a distance of \( x \) while the mass moves. Write an expression that gives the speed in terms of \( d \), \( x \), \( k_s \), and the mass, \( m \).
4) one object circular motion
   a. constructing a free body diagram to find the sum of the component forces that give $F_{\text{net}} = F_{\text{net,cent}}$. Remember, the centripetal force is not a real force but a description of how all the real, physical forces combine to cause circular motion.
   b. $F_{\text{net,cent}} = \frac{mv^2}{r}$

A 0.43 kg ball hangs from a pole by a rope (tether ball) at an angle of 25°. The ball moves in a perfect circle with a speed of 7.6 m/s. Find the length of the rope.

5) two objects connected
   a. share common $a_{\text{net}}$ magnitude: ex. $\frac{F_{\text{net,A}}}{m_A} = \frac{F_{\text{net,B}}}{m_B}$
   b. common situations
      1) two masses connected by rope and pulley

Two masses are connected by a rope that hangs over a fixed, frictionless pulley. One mass is 2.22 kg and the other is 3.33 kg. Find the acceleration of the blocks when allowed to move. Also find the upward force that must be exerted on the pulley to keep it stationary.
2) two masses on surface touching

Two masses on a surface are touching and a force is applied to one of them. If \( m_A = 4.6 \text{ kg} \) and \( m_B = 7.9 \text{ kg} \), and if the coefficient of friction of A is 0.6 and of B is 0.4, find the minimum force that needs to be applied to accelerate the masses. If twice this force is provided, find the acceleration of the masses.

6) two objects with forces on one another
   a. gravity between two objects, find \( F_G \)
      1) find \( g_{\text{surface}} \) for any planet given \( M \) and \( R \)

A large, dense planet has a mass of \( 5.54 \times 10^{28} \text{ kg} \) and a radius of \( 3.45 \times 10^6 \text{ meters} \). Find the gravitational acceleration at the surface.

   2) relate \( F_G \) to circular orbit centripetal acceleration on smaller mass orbiting larger mass

The planet in the previous problem has a moon of mass \( 2.54 \times 10^{22} \text{ kg} \). If it orbits with a speed of 12,345 m/s, what is the radius of its orbit?

Work (connecting forces to energy)

7) calculating work depending on the complexity of the situation
   a. one dimension, constant force: \( W = \pm Fd \)

A 62 kg person climbs a 6 m high vertical ladder at a constant 1.56 m/s velocity. Find the following amounts of work that were done on the person by each force: \( W_{\text{gravity}}, W_{\text{legs}} \) and \( W_{\text{net}} \).

   b. two dimensions, constant force: \( W = \vec{F} \cdot \vec{d} \)

A parent pulls a 38.3 kg child on a sled (of negligible mass) with a rope at a 73.0° angle above the horizon. The coefficient of friction is 0.05, and the parent pulls the child 10 meters with 70.2 N of force. If the child starts from rest, find the net work done on the child. What are the components of work that generate this net work on the child?
c. one dimension, position dependent force: \[ W = \int_{x_i}^{x_f} F(x) \, dx \]

A 0.86 kg mass is attached to a spring with a spring constant of 6 N/m and an equilibrium distance of 0.04 m. Find the work done by the spring on the mass if the mass is moved from the equilibrium position to 0.12 m away from the equilibrium position.

8) relating kinematics information to force information using \( W_{\text{net}} = \Delta K \)

A 297 kg object is falling straight down. 10 m above the ground, it has a speed of 15 m/s. Calculate the net work done on the falling object from its initial position of 10 m to where it hits the ground. Using this net work, find the speed of the object just before it struck the ground.

9) some special situations
   a. pulling wagons

   (see above)

   b. inclined planes

   You pull a tired friend up a mountain at a constant speed by means of a rope attached to your waists. The mountain has a 30° slope, and the rope is parallel to the ground. Your friend is able to lift their feet so that there is effectively no friction, but cannot aid at all in their own propulsion. If the friend (and gear) weighs 323 N, what is the amount of work you must provide to your friend to pull them each and every meter? What is the amount of work they do to you for a single meter? If you are able to maintain 0.5 m/s speed, what is the power you are doing to the friend?

   c. springs

   (see above)