1. [20 points]
   A projectile is launched from the origin at an angle of 51.4 degrees above horizontal (above the x axis) with a speed \( v = 47.8 \, \text{m/s} \). Assume that the only force acting on it is gravity. Let \( t = 0 \) when the projectile is launched.

   A) At what time \( t \) does it reach the highest point above the ground?

   B) How far downrange (distance along the x axis) is it at this time?

2. [5 points]
   An archer shoots an arrow. Consider the action force to be the bowstring against the arrow. The 3rd law reaction to this force is the

   A) grip of the archer’s hand on the bow.
   B) forward movement of the arrow.
   C) weight of the arrow.
   D) arrow’s push against the bowstring.
   E) friction of the ground against the archer’s feet.

3. [15 points]
   A 3.15 kg mass is on an inclined table that makes an angle of \( \theta = 19.4^\circ \) above horizontal. It is being pushed by a force of 29.8 N at an angle of \( \phi = 31.5^\circ \) above the incline, as shown in the drawing, and has a velocity of 2.77 m/s up the incline. There is friction, \( f \), acting on the mass.

   Draw a complete free-body diagram using a coordinate system parallel to the inclined table, being careful to show all force components in that coordinate system in terms of the given information.

4. [10 points]
   A satellite of mass 787 kg is in an orbit that is 2355 km above the surface of the earth. Find the force of gravity exerted on it by the earth.
5. [10 points]
   The position of a 6.73 kg mass is given by \( x(t) = (9t^3 - 12t^2) \) m, for \( t \) in s.

   A) What is the velocity, as a function of time?

   B) What is the force experienced by this mass, as a function of time?

6. [15 points]
   The 9.88 kg cart is moving to the right at 3.49 m/s at point A. A wind-up propeller on the cart does +54.9 J of work on the cart between A and B. The surface is frictionless.

   How high is the mass when it comes to rest on the hill?

7. [15 points]
   A 67 kg ice skater at rest on frictionless ice catches a 1.57 kg snowball that was coming from the northwest at a velocity of (+19.5 \( \hat{i} \) – 17.4 \( \hat{j} \)) m/s. Find the final (vector) velocity of the skater after she catches the snowball.

8. [15 points]
   The diagram below shows two masses connected by a massless spring that has a force constant of \( k = 517 \) N/m. The masses are \( M = 14.6 \) kg, \( m = 6.51 \) kg, and you know the friction coefficient between \( M \) and the table is 0.136. The force \( F \) is causing the system to accelerate to the right at 2.87 m/s\(^2\).

   Find (A) the tension \( T \) in the spring and (B) how much the spring stretches.

   (Hint: Draw a free-body diagram of mass \( M \).)