Answer all questions on the blue notebook provided. Show all your work and indicate your reasoning in order to receive most credit.

1. An arrow is shot into the air at an angle of 60° above the horizontal with a speed of $10 \times \sqrt{3}$ m/s $\approx$ 17.32 m/s.

   (a) What are the x- and y-components of the velocity of the arrow 3 s after it leaves the bowstring?

   (b) What are the x- and y-components of the displacement of the arrow during the 3 s interval?

   (c) What are the kinetic and the potential energy of the arrow 3 s after it leaves the bowstring assuming that its mass is 0.1 kg.

   (d) What is the arrow's flight time and the range before it hits the horizontal ground?

   For the purposes of solving this problem, assume the acceleration of gravity g = 10.0 m/s^2

2. In the middle of a cold night a pendulum oscillates with the period $T_1 = 1.00s$. During a hot day when the temperature rises by 200 $^\circ$ C the period of the same pendulum is $T_2 = 1.01s$. Find the termal expansion coefficient of the pendulum's string (Do not assume that the measurements took place on Earth!)

3. A horizontal merry-go-round is a solid disk of radius 2.0 m and mass 200 kg, started from rest by a constant horizontal force of 50 N applied tangentially to the edge of the disk. Frictional forces acting on the disk produce the torque 50 N·m. Find the kinetic energy of the disk after 3.0 s.

4. A uniform plank of length 6.00 m and mass 35.0 kg rests horizontally across two horizontal bars of a scaffold. The bars are 4.50 m apart, and 1.50 m of the plank hangs over one side of the scaffold.

   (a) How far can a painter with a mass of 70.0 kg walk on the overhanging part of the plank before it tips?

   (b) What are the forces on the plank from two support bars when the painter is in the middle of the plank? For the purposes of solving this problem, assume the acceleration of gravity g = 10.0 m/s^2

5. The water supply of a building is fed through a main pipe 9.00 cm in diameter. A 2.00 cm diameter faucet tap, located 2.00 m above the main pipe, is observed to fill a 24.0 L container in 30.0 s.

   (a) What is the speed at which the water leaves the faucet?

   (b) What is the gauge pressure in the 9.00 cm main pipe? (Assume the faucet is the only ”leak” in the building.)

6. The period of oscillation of a spring-and-mass system is 2π s $\approx$ 6.283 s and the amplitude is 10.0 cm.

   (a) What is the magnitude of the acceleration at the point of maximum extension of the spring?

   (b) What is the speed at the equilibrium point?

   (c) If the mass of the system is 1.0 kg what is its energy? (Neglect the mass of the spring.)

7. An 10.0 g bullet is fired into a 10.0 kg block initially at rest on a frictionless table. The bullet remains in the block, and after the impact the block slides with the velocity 1.0 m/s.

   (a) Find the initial velocity of the bullet.

   (b) Determine the the kinetic energy lost during the impact.

8. A woman at an airport is towing her 20.0 kg suitcase at constant horizontal acceleration $a = 0.1$ m/s^2 by pulling on a strap at an angle above the horizontal. She pulls on the strap with a 40.0 N force, and the friction force on the suitcase is 20.0 N.

   (a) What is the kinetic energy of the suitcase 5 seconds after it starts moving from rest?

   (b) What angle does the strap make with the horizontal?

   (c) What normal force does the ground exert on the suitcase?

   For the purposes of solving this problem, assume the acceleration of gravity g = 10.0 m/s^2

9. A 10.0 m uniform ladder weighing 500 N rests against a frictionless wall. The ladder makes a $60.^\circ$ angle with the horizontal. Find the horizontal and vertical forces the ground exerts on the base of the ladder when an 800 N firefighter is 4.0 m from the bottom. For the purposes of solving this problem, assume the acceleration of gravity g = 10.0 m/s^2.

10. A 10 L sample of an ideal gas with $\gamma = \frac{5}{3}$ is at 27°C and 50kPa. The ga is compressed adiabatically until its pressure triples, then cooled at constant volume back to the original temperature, and finally allowed to expand isotermaaaally to its original state.

    (a) How much work is done on the gas?

    (b) What is the minamal volume reached?