Name: _____ Block: _____ Unit 5 Problems: Energy

5A: Types of Energy and 5B: Kinetic and Gravitational Potential Energy

1) What type(s) of energy are present in each of the following scenarios?
    a) Christmas tree lights are powered by a 12 V battery.
    b) A sports car races down the highway.
    c) A spring is forced down by a heavy weight.
    d) 4 kg of iron oxide and 2 kg of aluminum ignites, releasing heat.
    e) A book about Antebellum America sits on a high shelf.
    f) Thomas Edison's first light bulb lights up and is hot to the touch.
    g) A battery powered flashlight is turned on in an emergency
    h) The internal compass needle in your smartphone snaps into alignment with the Earth's magnetic field.

2) Frank the pet rock weighs 100 N and is on a shelf 4 meters above the ground. It is gliding along the shelf at a constant speed of 3 m/s.

    a) What is the momentum of the rock?
    b) What is the acceleration of the rock?
    c) What is the kinetic energy of the rock?
    d) What is the gravitational potential energy of the rock?
    e) What is the total energy of the rock?

3) Mr. Forcier (90 kg) is jogging along at a speed of approximately 12 km/hr when he slows down to a speed of approximately 9 km/hr over the course of 4 seconds.
    a) Convert Mr. Forcier's initial and final speeds to m/s.
    b) What is Mr. Forcier's acceleration?
    c) Calculate Mr. Forcier's initial kinetic energy.
    d) Calculate Mr. Forcier's initial gravitational potential energy .
    e) Calculate Mr. Forcier's final kinetic energy.
    f) If Mr. Forcier was travelling South the entire time, what would the direction of his acceleration be?

5C: Conversion of Energy

4) Come up with a situation in which the following energy transformations take place:
    a) Chemical potential energy is transformed into thermal energy.
    b) Kinetic energy is transformed into electrical energy.
    c) Electrical energy is transformed into chemical potential energy.
    d) Kinetic and gravitational potential energy is turned into thermal energy.

5) You are a personal trainer creating a meal plan for a client. For breakfast they consume 3 cups of fruity pebbles (440 Calories), 1 cup of whole milk (100 Calories) and one frosted blueberry pop tart (200 Calories). You estimate that at rest your body burns 80 Calories per hour. An average push up burns about 3 Calories. (1 Calorie = 4184 J)

   a) What type of energy is contained in the food?
   b) What type(s) of energy is the food converted to when you are exercising?
   c) How many push ups do you have to do if you want to burn up all of the Calories from breakfast in 2 hours?

6) Diagram the conversion of energy for the following situations
   a) An electrical signal from a neighboring nerve cell causes molecules to change their bonds in a muscle cell.
   b) A proton speeds up as it zips across an electric field.
   c) A lion finishes eating its meal and then starts running after its next prey.
   d) A mover pushes couch across a rough piece floor causing the bottom of the couch to heat up from friction.

7) You are about to be late to school, so you decide to cover the 8 mile distance to school at 1.5 times the 30 mph speed limit. Assume the drive is mostly straight road. (1600 m = 1 mile)

   a) How many minutes would it have taken you to get to school going the speed limit?
   b) How many minutes would it have taken you to get to school speeding?
   c) How much time did you save by speeding?
   d) What is the kinetic energy of your 2000 kg car if you are traveling the speed limit?
   e) What is the kinetic energy of your 2000 kg car if you are speeding?
   f) How many times does your car's kinetic energy increase if you double the velocity of the car?

5D: Conservation of Energy* and *5E: Energy Conservation Problem Solving

8) For each of the following situations write out a simplified conservation of energy equation. (Ex: U_G=K for a rock dropped off a cliff). Remember to use the correct abbreviations for each type of potential energy.
   a) A ball moving at 8 m/s rolls down a frictionless hill.
   b) Jenny knocks a milkshake off of the counter and it hits the floor.
   c) An electron is accelerated as it passes through a magnetic field.
   d) 6 ounces of ammonium nitrate propels a toy car across a frictionless floor.
   e) Ezio throws a superball at the ground and it bounces 10 m in the air.
   f) A student pulls back a slingshot and then fires a marble at a cloud.

9) You are in your 3rd floor apartment watching the 8th season of Sesame Street, when you wonder how fast your remote would be traveling if you dropped it out of the window. You estimate that your apartment is 10 meters off of the ground and that your remote has a mass of 80 g.
   a) Solve for the velocity of the remote right before it hits the ground using kinematics.
   b) Solve for the velocity of the remote right before it hits the ground using energy conservation.
   c) Which method did you like better? Explain why.

10) A 30 g toy car sits next to a compressed spring the spring stores 40 J of energy. The spring goes off and pushed the toy car up a frictionless ramp.
   a) Diagram the energy conversion.
   b) How fast would the toy car be moving it was 5 m high on the ramp? 12 m?
   c) Would the car move up the ramp faster if it had less mass? Explain why.

11) A group of friends are on Hole 17 of a mini-golf course, which consists of hitting the ball down a steep hill. The 0.15 kg golf ball has a gravitational potential energy of 25 J at the top of the hill and is given 9 J of kinetic energy from the golfer's swing. Halfway down the hill, the golf ball has a gravitational potential energy of 15 J. At the bottom of the hill, the golf ball has a gravitational potential energy of 5 J. Assume no friction. You want to find the speed of the ball at the bottom of the hill.
   a) Sketch the hill and the ball.
   b) Calculate the total initial energy of the golf ball.
   c) What types of energy are present at your final point?
   d) What is the total final energy of the golf ball?
   e) Calculate the speed of the golf ball at the bottom of the hill.

5F: Work

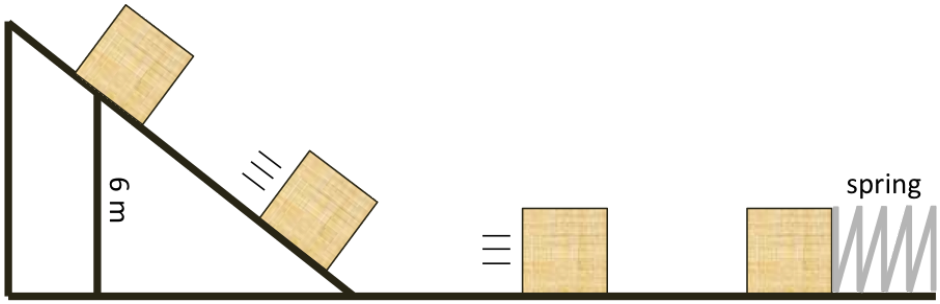
12) For each of the following situations identify if positive or negative work is being done.
    a) A car brakes just in time before hitting a box of rocks.
    b) Delmar is pulled in a wagon by a local penguin.
    c) A child drops a super ball and it slowly stops bouncing.
    d) Eunice is brought to the top of the mountain by a chairlift.

13) A small child is t the top of a snowy hill with his sled. He and his sled have 900 J of gravitational potential energy at the top of the hill. As he slides down the hill, friction between the sled and the slope cause 400 J to be converted to thermal energy.
    a) What is the total initial energy of this situation?
    b) The initial gravitational potential energy is converted to two different types of energy as the child sleds down the hill. Name both of them.
    c) What is doing work on the sled? How much work is being done.
    d) How much kinetic energy does the child have at the bottom of the hill?

14) A youth basketball handbook states: "The ball shall be inflated to an air pressure such that when it is dropped to the playing surface from a height of 6 feet it shall rebound to a height of at least 49 inches". Assume you are playing with a basketball (.625 kg) that just meets this standard. (1 in = 2.54 cm)

    a) Diagram the conversion of energy from the time the ball is dropped until the time it reaches it maximum bounce height.
    b) How much energy does the ball contain right as it is dropped?
    c) How much energy does the ball contain right as it reaches its maximum bounce height?
    d) How much work is done on the ball?

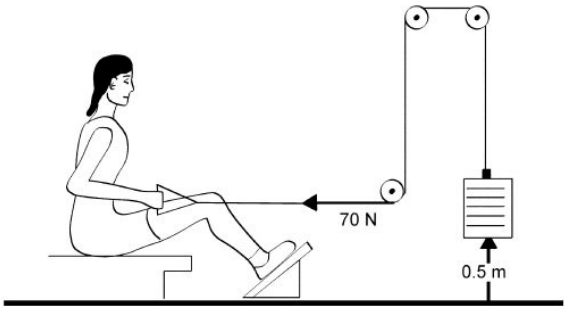
15) A 296 kg box of unused 3rd editions of Paul Hewitt's *Conceptual Physics* is placed on a ramp 6 meters above the ground. It slides down the frictionless ramp onto a frictionless floor. It then runs into a spring that is fastened to the wall and briefly comes to a stop.



a) Is energy conserved in this situation? Explain why or why not.
b) How much gravitational potential energy does the box have when it is placed on the ramp?
c) How fast does the box slide across the floor before it hits the spring?
d) How much energy is stored in the spring when it is fully compressed?
e) After the box comes to a stop, it is shot back across the floor and up the ramp. It comes to a stop at some point on the ramp. How far above the ground will it be when it stops?
f) Will the box ever stop moving? Explain.
g) If the floor exerts a frictional force on the box, would the box stop moving? Would work be done on the box?
h) Diagram the conversion of energy if the floor exerts a frictional force.

16) A woman is working out on a rowing machine, pulling a stack of weights with 70 N of force.

a) Draw the free body diagram of the woman.
b) Draw the free body diagram of the weights.
c) How much does the stack of weights weigh if the woman lifts them with at a steady rate?
d) How much work does the woman do on the weights to lift them .5 m of the ground?



5G: Power

17) How much energy does a 100 W lightbulb use if you leave it on for 24 hrs? The lightbulb has a mass of .04 kg.

18) For each of the following electronics, would you want a battery that has a large power rating but cannot store a lot of energy or a battery than has a small power rating but can store a lot of energy?
    a) Path lights in the park need to be kept on all night long but can be kept at a dim luminescence.
    b) A disposable electric rocket launcher only needs to be used once but needs to get a rocket going really fast in a really short amount of time.
    c) A defibrillator needs to turn all of its energy into electrical energy in a fraction of a second and can be quickly recharged as needed.
    d) A set of 2016 light-up glasses only contains a few small light bulbs, but needs to stay on all night through and past the countdown on New Year's Eve.

19) You are a sprinter and are looking to increase your explosiveness (power). You are debating between two different exercises. Exercise A has you lifting 15 kg of weight vertically 12 times in 30 seconds. Exercise B has you lifting 20 kg of weight vertically 8 times in 18 seconds. Assume you always lift the weight to the same height.
    a) Which exercise requires you to do more work?
    b) Which exercise requires you to exert more power?
    c) Which exercise make more sense for your fitness goal?

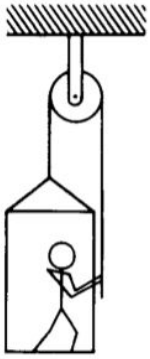
20) You are a physical trainer tasked with measuring an athlete's power output using the "Vertical Jump Test". For this test the athlete (700 N) jumps as high as they can and you record this height (17 in). (1 in = 2.54 cm)
    a) How many meters did the athlete jump?
    b) Diagram the conversion of energy from the time they begin to jump until the time that they hit the ground.
    c) What was the athlete's velocity right as they left the ground?
    d) How much energy does the athlete have at the top of their jump?
    e) How much work is done by the athlete?
    f) How much power is the athlete exerting if it takes them .2 to push off the ground?

Challenge Problems:

5A/5B/5C

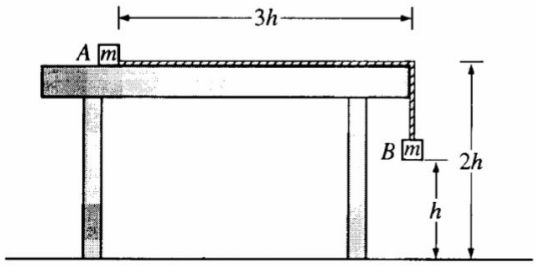
1) A helicopter holding a 70 kilogram package suspended from a rope 5.0 meters long accelerates upward at a rate of 5.2 m/s^2. Neglect air resistance on the package.
   a) Draw a free body diagram for the package.
   b) Determine the tension in the rope.
   c) When the upward velocity of the helicopter is 30 meters per second, the rope is cut and the helicopter continues to accelerate upward at 5.2 m/s^2. Determine the distance between the helicopter and the package 2.0 seconds after the rope is cut.

2) The figure shows an 80 kilogram person standing on a 20 kilogram platform suspended by a rope passing over a stationary pulley that is free to rotate. The other end of the rope is held by the person. The masses of the rope and pulley are negligible. Assume that friction is negligible, and the parts of the rope shown remain vertical.



   a) If the platform and the person are at rest, what is the tension in the rope? The person now pulls on the rope so that the acceleration of the person and the platform is 2 m/s^2 upward.
   b) What is the tension in the rope under these new conditions?
   c) Under these conditions, what is the force exerted by the platform on the person?

3) Two small blocks, each of mass m, are connected by a string of constant length 4h and negligible mass. Block A is placed on a smooth tabletop as shown above, and block B hangs over the edge of the table. The tabletop is a distance 2h above the floor. Block B is then released from rest at a distance h above the floor at time t=0. Express all algebraic answers in terms of h, m, and g.

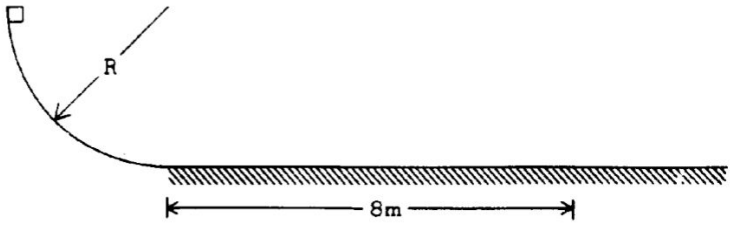


   a) Determine the acceleration of block B as it descends.
   b) Block B strikes the floor and does not bounce. Determine the time t at which block B strikes the floor.
   c) Describe the motion of block A from time t = 0 to the time when block B strikes the floor.
   d) Describe the motion of block A from the time block B strikes the floor to the time block A leaves the table.

5D/5E

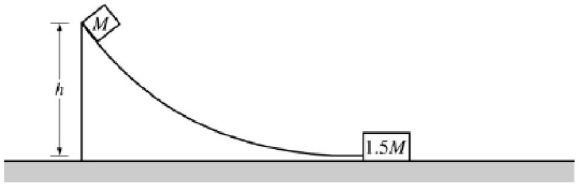
4) A helicopter is moving upwards at 12 m/s. A passenger drops a bag of candy 200 m above the ground. How fast is the bag of candy moving when it hits the ground? Solve using the conservation of energy.

5) A 2 kilogram block is released from rest at the top of a curved incline in the shape of a quarter of a circle of radius R. The block then slides onto a horizontal plane where it finally comes to rest 8 meters from the beginning of the plane. The curved incline is frictionless, but there is an 8 newton force of friction on the block while it slides horizontally.



a) Determine the magnitude of the acceleration of the block while it slides along the horizontal plane.
b) How much time elapses while the block is sliding horizontally?
c) Calculate the radius of the incline in meters.

6) A small block of mass M is released from rest at the top of the curved frictionless ramp shown above. The block slides down the ramp and is moving with a speed 3.5 v_i when it collides with a larger block of mass 1.5M at rest at the bottom of the incline. The larger block moves to the right at a speed $2v_i$ immediately after the collision. Express your answers to the following questions in terms of the given variables.



a) Determine the height h of the ramp from which the small block was released.
b) The larger block slides a distance D before coming to rest. Determine the value of the force of friction between the larger block and the surface on which it slides.