Unit Plan: Energy and Work – Deadfall Traps

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Acknowledgements, Deadfall Trap Activity: Barry Linklater (ITEP), Dr. Sean Maw (U of S College of Engineering)

Grade Level: 12 **Subject:** Physics 30 **Time Frame (Duration):** 7 hours

Outcomes/Indicators (from Curriculum Document):

PH30-CO1 Investigate the nature of kinetic, potential, and total mechanical energy, including the law of conservation of energy.

a. Determine the conditions required for positive, negative, and zero mechanical work. (K, S)
b. Explain the relationship between work and energy. (K)
d. Solve problems related to kinetic, potential, and total mechanical energy in which objects move with and without the presence of friction. (K, S)
e. Design and perform an experiment involving transformations of potential and kinetic energy, including collecting, analyzing and interpreting data.

Specific SMART Goal:

Student will be able to calculate work done on an object as well as potential energy and kinetic energy of an object.

Assessment (Must Assess SMART Goal):

Formative assessment will be student completing the practice problems and making correction for each question they got wrong. Both assignment and corrections will be handed in so the teacher can gauge knowledge and ability.

Summative assessment will be a lab quiz completed by students in class after the lab to see if they understood the process of the lab, what they were measuring, and how it was being measured.

Student Materials and Teacher Resources: Lab instructions and lab assessment are attached

Lessons:

<u>Potential Energy (1 hr)</u>

Introduction/Background Building: (15 min)

Recall: An object undergoes the force of gravity when it is dropped. It experiences constant acceleration (g) and is of a specific mass (m), so we can calculate the force of gravity, F=mg.

Ask the students to consider: is it different if an object is dropped from a small distance compared to a large distance? Use an egg to demonstrate (5 min) (if dropped from 1 cm, it will crack, however if dropped from 1-2m, it will smash). Discuss why the two are different.

Teacher Directed Activities (Modeling): (20 min)

We describe objects above a particular surface (here the ground) as having a certain potential energy, which depends on the force of gravity, F=mg, as well as height (h). So, PE = mgh.

Discuss relationships between PE and m, g, and h. (i.e. if PE is constant and m increases, then h must decrease, etc).
Discuss the importance of determining the reference level, i.e. if an egg is dropped above a table from eye level, it will have a different PE than if it is dropped from eye level to the floor.
Do an example problem of solving for a particular variable from PE = mgh.
Student Directed Activities (Practice): (20 min)
Give students time to work on practice problems
Conclusion/Culminating Set (Reinforce the lesson): (5 min)
Reinforce that potential energy depends on mass, gravity and height.

Kinetic Energy (1 hr)
Introduction/Background Building: (15 min)
Recall: Constant acceleration formulas. Ask students if an object starts at zero velocity, and undergoes constant acceleration for a particular distance, how will the final velocity compare to an object undergoing the same acceleration for a greater distance? (such as accelerating a car for one block vs accelerating for two blocks)
Refer back to the egg – was the final velocity different for the one that cracked compared to the one that smashed?
Teacher Directed Activities (Modeling): (20 min)
We describe an object in motion as having kinetic energy, which depends on mass and velocity according to $KE = 1/2mv^2$. Discuss the relationships between KE and m and v. (i.e. if m increases, KE increases, etc)
Do an example problem of solving for a particular variable from $KE = 1/2mv^2$
Student Directed Activities (Practice): (20 min)
Give students time to work on practice problems.
Conclusion/Culminating Set (Reinforce the lesson): (5 min)
Reinforce that kinetic energy depends on mass and velocity.

Conservation of Energy (1 hr)
Introduction/Background Building: (25 min)
Have a discussion guided by the following questions:

> How are potential energy and kinetic energy related?
> As an object drops, its height decreases, so PE decreases. Where does the energy go?
> How is the velocity changing as an object drops?

Allow students to use simulation: (10 min)
https://phet.colorado.edu/sims/html/energy-skate-park-basics/latest/energy-skate-park-basics_en.html - What do you notice about total energy?
Teacher Directed Activities (Modeling): (20 min)
We say that total energy of a system never changes – it is always constant, though it may change its form. Ei = Ef, and E= KE + PE, so KEi + PEi = KEf + PEf
Discuss situations where mechanical energy isn't conserved (friction causing heat, sound, etc)
Do two example problems.
Student Directed Activities (Practice): (10 min)
Do practice problems.
Conclusion/Culminating Set (Reinforce the lesson): (5 min)
Reinforce that energy is never created nor destroyed, only transformed.

Work (1 hr)

Introduction/Background Building: (10 min)

Discussion guided by following questions:

How do we increase an object's potential energy?

What do *you* have to do to make that happen?

What happens when you exert a force?

Teacher Directed Activities (Modeling): (25 min)

Positive work is done on an object when a force is applied in the same direction as the movement of the object. $W = F\Delta d$

Demonstration – teacher in rolling chair (10 min). How do we move him? Student must exert force in the direction they want him to move. They do work on the teacher/chair system. Then the teacher puts his feet down (to increase friction), so pushing force must increase to overcome friction, thus the student does more work on the teacher/chair system. Variation: decrease mass of system by asking a smaller student to sit in the chair, so less work required.

Discuss positive vs negative work – friction does negative work on the teacher/chair system because frictional force is always applied in opposite direction of movement.

Discuss zero work – when force is applied in direction perpendicular to movement – carrying a box 10 meters requires no work because force is vertical, movement is horizontal. Potential energy doesn't change, because no work is done. Work is required to change potential energy.

When you accelerate an object, you are doing work against inertia. That work equals the change in kinetic energy of the object.

Discuss what happened when the students pushed the chair.

It started moving. Once something with mass has a velocity it has a certain kinetic energy.

Once the student put work into the chair its kinetic energy changed from 0 to some given value which depends on its final velocity

Therefore, $W = \frac{1}{2}mv_f{}^2 - \frac{1}{2}mv_i{}^2 = KE_f - KE_i = \Delta KE$

Student Directed Activities (Practice): (20 min)

Do practice problems.

Conclusion/Culminating Set (Reinforce the lesson): (5 min)

Work is only done when force is applied in the same direction as motion.

Deadfall trap lab (2 hrs)

Introduction/Background Building: (20 min)

Discuss traditional use of deadfall traps by First Nations people to trap large animals such as bears, with the knowledge being passed down orally by trappers. They were considered a quick, human kill when designed correctly (a rule of thumb is to have the weight be three times heavier than the animal to be trapped). They are no longer legal for use in Saskatchewan. Discuss reasons why legislation may have changed over the years (potentially too effective, population decreases, etc)

Explain how the trap works, and the intricacies of designing a trap. Discuss other physical concepts that are at work in the trap such as friction, torque, etc. Note that explaining the trap and trigger system as a whole would be a second year engineering assignment.

Discuss how the trap reflects First Nations worldview – using materials in the environment for survival, only taking what you need from the earth, and wasting as little of the animal as possible.

If necessary, instruct students on the concept of center of gravity as used in the lab (we can treat the entire board as a point mass because splitting up the board into smaller pieces and calculating the kinetic energy of each piece and adding them up is equal to finding the kinetic energy of the board as a point mass at the center of gravity).

Teacher Directed Activities (Modeling): (5 min)

Show students how to set up the trap, and walk them through the steps they will be doing in the lab (see attached).

Student Directed Activities (Practice):

Students complete part A of the lab and clean up. (35 min)

In the next class, students set up again, complete part B and clean up. (30 min)

Students complete results and calculations and conclusion portions of the lab and hand in (20 min)

Conclusion/Culminating Set (Reinforce the lesson): (10 min)

Answer any questions about the lab itself.

Discuss the students' findings and how it reinforces concepts already covered in lessons.

<u>Lab Assessment (1 hr)</u>

Students complete attached lab assessment.