

CALCULUS-BASED PHYSICS-1: MECHANICS (PHYS150-01): WEEK 7

Jordan Hanson

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Whittier College Department of Physics and Astronomy

WEEK 6 REVIEW

1. **Work** has a scientifically precise definition
 - Units
 - As a product of force and displacement vectors
2. Kinetic Energy and the **Work-Energy Theorem**
3. Gravitational potential energy
 - Potential energy
 - *Simplifying otherwise complex calculations*
 - Potential energy near Earth's surface
 - ...in space
4. Definition of a **conservative force**
 - Relationship between conservative forces and potential energy
 - Conservation of energy for conservative forces

WEEK 6 REVIEW PROBLEMS

Recall that the *gravitational potential energy* associated with an object of mass m located a height y above ground level is $U = mgy$. What is $-dU/dy$?

- A: mg
- B: $-mg$
- C: g
- D: $-g$

What is the physical meaning of the quantity $-mg = -dU/dy$?

- A: The force of gravity
- B: The acceleration due to gravity
- C: The mass
- D: Change in kinetic energy

WEEK 7 SUMMARY

1. **Work** and **potential energy**
 - **Lab activity:** Oscillator and gravity trading work and potential energy
2. Potential energy and **conservative forces**
3. **Conservation of Energy**
 - *Calculus review: the fundamental theorem of calculus*
 - Graphical representations of integrals and energy

WORK AND POTENTIAL ENERGY

WORK AND POTENTIAL ENERGY

When we do work on a system, even if in the final state the system has no velocity, it can still have energy. The concept of *potential energy* is **like thinking of work backwards**:

- If we compress an oscillator (a spring), and keep compressing it, it has no kinetic energy but it will have kinetic energy if we release it.
- If we raise an object against the force of gravity to a certain height, it has no kinetic energy but it will have kinetic energy if we drop it.
- But it took work to create this change in kinetic energy, from the work-energy theorem.

*Systems are not necessarily **required** to operate like this...Think of stretching plastic or dough. Where does the work go?*

The relationship between work and potential energy therefore resembles (by definition) the opposite of the work-energy theorem:

$$\Delta U_{AB} = U_B - U_A = -W_{AB} \quad (1)$$

WORK AND POTENTIAL ENERGY

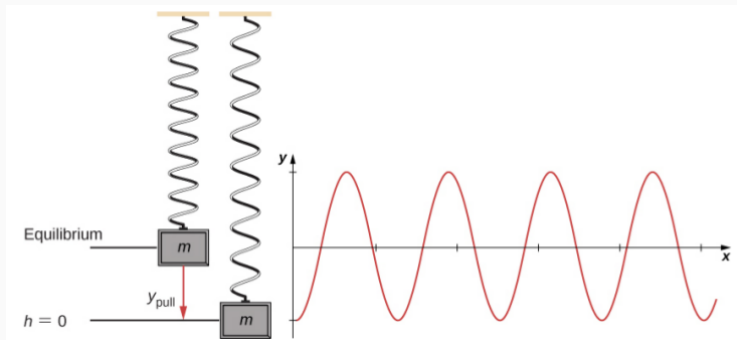


Figure 1: An oscillator is stretched to a new equilibrium point by gravity. When pulled a certain distance down, or compressed a certain distance upwards, y_{pull} , we observe oscillation.

WORK AND POTENTIAL ENERGY

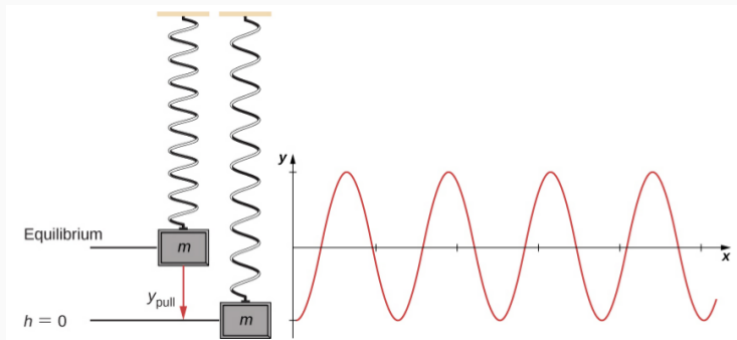


Figure 2: Notice that it does not matter what the observer defines as zero potential energy, since work is required to perform *changes* in potential energy.

WORK AND POTENTIAL ENERGY

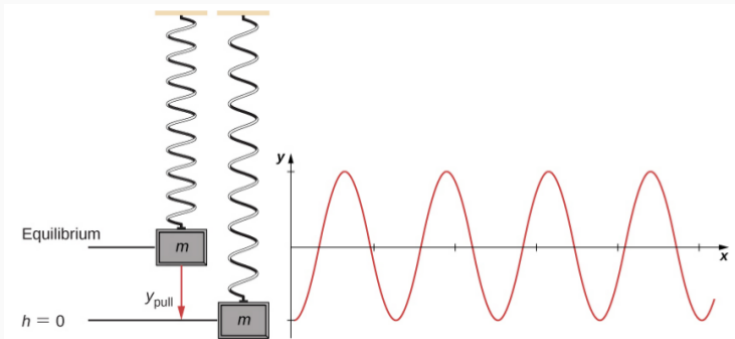


Figure 3: The fact that work is required only to perform changes in potential energy, but not does not determine the *absolute* scale of potential energy, means the observer may choose the location of zero potential energy, in the same fashion as choosing a coordinate system.

	Gravitational P.E.	Elastic P.E.	Kinetic E.
(3) Highest Point	$2mgy_{\text{pull}}$	$\frac{1}{2}ky_{\text{pull}}^2$	0
(2) Equilibrium	mgy_{pull}	0	$\frac{1}{2}mv^2$
(1) Lowest Point	0	$\frac{1}{2}ky_{\text{pull}}^2$	0

Figure 4: If a mass m is connected to the oscillator and we choose the potential energy zero-point to be **the low point of oscillation**, the values listed in this table correspond to the energies at various states.

LAB ACTIVITY - GRAVITY AND THE OSCIL- LATOR

LAB ACTIVITY: WORK AND POTENTIAL ENERGY

- Using the springs, weights, hooks, and system of clamps and grips, build a vertical oscillating system.
- Diagram the system, showing a clearly defined value for y_{pull} , and a clearly defined choice for the potential energy zero-point.
- Measure the *unstretched* spring length, and the *equilibrium length* caused by gravity, to **derive the spring constant k** . Quote the value of k in N/m.
- Pull the spring downwards by y_{pull} , and record the maximum and minimum heights of the weight as the spring oscillates it.
- Create a table like Tab. 4, and fill in the actual energy values in Joules. What is your predicted value for v , the speed at which the weight moves when the oscillator is at the equilibrium position?

	Gravitational P.E.	Elastic P.E.	Kinetic E.
(3) Highest Point	$2mgy_{\text{pull}}$	$\frac{1}{2}ky_{\text{pull}}^2$	0
(2) Equilibrium	mgy_{pull}	0	$\frac{1}{2}mv^2$
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Figure 5: If a mass m is connected to the oscillator and we choose the potential energy zero-point to be **the low point of oscillation**, the values listed in this table correspond to the energies at various states.

CONCLUSION

ANSWERS

- $-mg$
- The force of gravity
- ...