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AP Physics Review Sheet
4/28/26

Chapter 8: Potential Energy

Background: Unit 8 in AP Physics builds on the idea of work and introduces potential energy, which is stored energy in a system. It focuses on two main types: gravitational potential energy (energy an object has because of its height near Earth) and elastic potential energy (energy stored in stretched or compressed springs). The unit explains that when there is no friction or air resistance, the work done on an object is related to changes in potential energy and depends only on the starting and ending positions. Overall, Unit 8 explores how energy is conserved when only conservative forces act, how non-conservative forces like friction reduce mechanical energy, and how potential energy diagrams can be used to understand motion and energy changes.

Major Topics:

1. Potential Energy of a System
2. Conservative and Non-Conservative Forces
3. Conservation of Energy
4. Potential Energy Diagrams and Stability
5. Sources of Energy

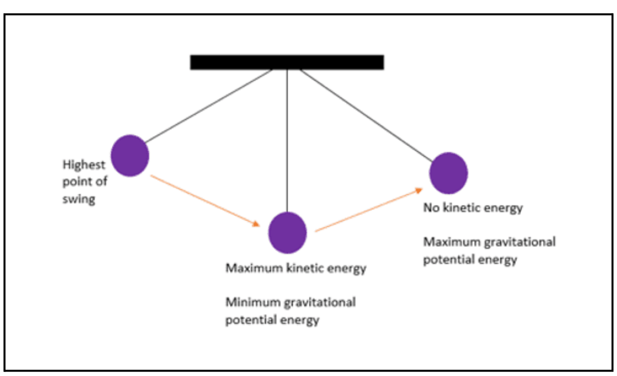
Key Phrases/Vocabulary:

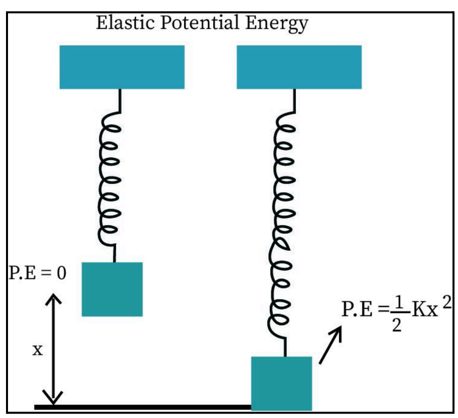
- **Energy Conservation:** the total energy of an isolated system is constant; it is not created or destroyed, but may be transformed between different forms of energy
- **Mechanical energy:** the sum of the kinetic and potential energies in a system
- **Potential Energy:** the energy stored within an object or system due to its position, arrangement, or state, rather than its motion
    - **Gravitational potential energy:** energy stored due to an object's height above a reference point
    - **Elastic (spring) potential energy:** energy stored in a stretched or compressed spring
- **Conservative forces:** forces that exist when the work done by that force on an object is independent of the object's path
- **Non-conservative forces:** forces that take energy away from the system as the system progresses (friction or air resistance)
- **Work:** energy transferred by a force through a distance

Formulae:

Concept	Formula	Variables
Gravitational potential energy	$U_g \; or \; PE_g = mgh$	m: mass(kg) g: acceleration due to gravity h: vertical height above a reference level (m)
Elastic potential energy	$U_s \; or \; PE_s = \frac{1}{2}kx^2$	k: spring constant (N/m) x: displacement from equilibrium (m)
Mechanical energy	$E = K + U$	K: kinetic energy $(\frac{1}{2}mv^2)$ U: potential energy $(U_g + U_s)$
Conservation of mechanical energy	$\sum E_{initial} = \sum E_{final}$ $K_i + U_i = K_f + U_f$	K_i: initial kinetic energy U_i: initial potential energy K_f: final kinetic energy U_f: final potential energy
Work by conservative forces	$W =- \Delta U =- (U_f - U_i)$	See same variables above
Force from potential	$F_x =- \frac{du}{dx}$	F_x: force $\frac{du}{dx}$: change in potential energy

Diagrams:





Problems:

(Easy) Ignoring details associated with friction, extra forces exerted by arm and leg muscles, and other factors, we can consider a pole vault as the conversion of an athlete's running kinetic energy to gravitational potential energy. If an athlete is to lift their body 4.8 m during a vault, what speed must they have when they plant the pole?

(Medium) A girl on a skateboard (total mass of 40 kg) is moving at a speed of 10 m/s at the bottom of a long ramp. The ramp is inclined at 20° with respect to the horizontal. If she travels 14.2 m upward along the ramp before stopping, what is the net frictional force on her?

(Hard) A block of mass 500 g is attached to a spring of spring constant 80 N/m. The other end of the spring is attached to a support, while the mass rests on a rough surface with a coefficient of friction of 0.20 that is inclined at an angle of 30°. The block is pushed along the surface till the spring compresses by 10 cm and is then released from rest. (a) How much potential energy was stored in the block-spring-support system when the block was just released? (b) Determine the speed of the block when it crosses the point where the spring is neither compressed nor stretched. (c) Determine the position of the block where it just comes to rest on its way up the incline.

Answers:

Easy

$h = 4.8\,m$

$\sum E_i = \sum E_f$

$K_i + U_i = K_f + U_f$

$\frac{1}{2}mv^2 + 0 = 0 + mgh$

$\frac{1}{2}mv^2 = mgh$

$\frac{1}{2}v^2 = gh$

$v^2 = 2gh$

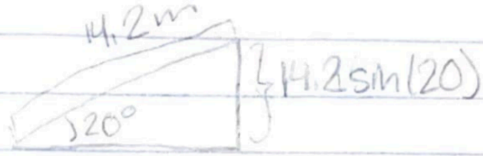
$v = \sqrt{2gh}$

$v = \sqrt{2(9.8)(4.8)}$

$v = 9.70\,m/s$

Medium

m = 40 kg
$v_i = 10$ m/s
$\theta = 20°$
d = 14.2m



– we know our height needed to use $U_g = mgh$

$\Sigma E_i = \Sigma E_f$

$K_i + U_i = K_f + U_f + \Delta E$ ← caused by frictional force

$K_i + 0 = 0 + U_f + \Delta E$

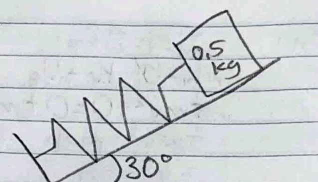
$\frac{1}{2}mv^2 = mgd\sin\theta + F_f d$

$\frac{1}{2}(40)(10)^2 = (40)(9.8)(14.2\sin(20)) + F_f(14.2)$

$F_f = 6.8N$

Hard

m = 500g → 0.5 kg
k = 80 N/m
μ = 0.20
θ = 30°
x = 10cm → 0.10m



a) $U_s = \frac{1}{2}kx^2$

$U_s = \frac{1}{2}(80)(0.10)^2$

$U_s = 40(0.01) = \boxed{0.40J}$

↳ spring potential energy

b) $h = x\sin(30°)$

$= (0.10)\sin(30) = 0.05m$

$U_g = mgh$

$= (0.5)(9.8)(0.05)$

$= 0.245J$ → energy lost due to gravity

$F_N = mg\cos(30)$

$(0.5)(9.8)(0.866) = 4.24N$

$F_f = \mu F_N = (0.2)(4.24) = 0.848N$

$W_f = F_f d = (0.848)(0.10) = 0.0848J$

$KE = U_s - E_{lost} - W_f$

$= (.40) - (0.245) - (0.0848)$

$= 0.0702J$

$KE = \frac{1}{2}mv^2$

$0.0702 = \frac{1}{2}(0.50)v^2$

$\boxed{v \approx 0.53 m/s}$

c) $mg\sin(30) + \mu mg\cos(30)$

$(0.5)(9.8)(0.5) + (0.2)(0.5)(9.8)(0.866)$

$= 3.29N$

KE = Fd

$0.0702 = 3.29d$

d = 0.0213 m

$0.10 + 0.021 = \boxed{0.121m}$