Name ______________________________ **Unit 4: Energy, Work and Power**

Topic 4A: ENERGY-WORK THEOREM

$W=Fd = \Delta E_T$ $KE = \frac{1}{2}mv^2$ $PE = mg\Delta h$ $PEs=\frac{1}{2}kx^2$ $P=\frac{W}{t}=\frac{Fd}{t}=F\bar{v}$

Students will be able to:

Skill 28:

- ☐ Calculate quantity of energy (KE, PE or PE_s) given a combination of mass, vertical position, velocity, stretch or compression of a spring and spring constant.
- ☐ Provide the definitions, variables and equations for the work, kinetic energy and potential (gravitational) energy and elastic (spring) potential energy.
- ☐ Assign the units of Joules (J) to work and forms of energy
- ☐ Sketch the graphs of kinetic energy vs speed, potential (gravitational) energy against mass or height and, elastic (spring) potential against stretch of a spring.

Skill 29:

- ☐ Identify the types of energy possessed by an object and relate to the type of work done to give the object energy in FRICTIONLESS SYSTEMS. (Skill 29)
  - o Work done (vertically) against gravity results in gravitational potential energy
    - $W_{vertical}=F_gd= F_gh = mgh$
  - o Work done (horizontally) to increase the speed of an object results in a gain of kinetic energy
    - $W_{horizontal} = Fd = mad = \frac{1}{2}mv^2$ ($v_f^2=v_i^2+2ad$ so $ad = ½ v^2$)
  - o Work done on a spring results in elastic potential energy
    - $W_{spring} = \overline{F}_s d = \overline{F}_s x = 1/2\ kx\ (x) = ½\ kx^2$
      (on a Fs vs x graph it is the area bound by the line)
  - o Define internal energy (Q) as the loss of energy to the system (heat) due to friction **$W= F_fd = E_T = Q$**

Skill 30:

- ☐ Provide the definition and equation for power
- ☐ Explain the relationship between power, work and time
- ☐ Calculate power given work and time; force distance and time; or force and average speed

Topic 4B: CONSERVATION OF ENERGY

$$E_T=PE + KE + Q$$

Students will be able to:

Skill 31

- o Understand how energy changes from one form to another in horizontal system
  - o Determine the amount of work needed to generate a specific amount of kinetic and/or internal energy

- Understand how energy changes from one form to another in a vertical system
    - Determine the change in potential/kinetic or internal energy in a system in which height, speed, and/or temperature change
    - Calculate unknowns such as initial speed, final speed, change in speed, height, stretch or compression of a spring given total energy of the system in an equivalent format.

Skill 32

- ☐ Define the term internal energy
    - Determine the amount of work done by friction in a horizontal system given a discrepancy in or loss of kinetic energy
    - Determine the amount of work done by friction in a system given a discrepancy between starting and ending total mechanical energies.

Topic 4A: Energy Work and Power

Skill 28: Forms of Energy

Topic 4A: Energy Work and Power

Skill 29: Work Energy Theorem

Skill 30: Power

Topic 4B: Conservation of Energy

Skill 31: Conservation of Energy

Topic 4B: Conservation of Energy

Skill 32:

$$F_s = kx$$

$$PE_s = \frac{1}{2}kx^2$$

$$\Delta PE = mg\Delta h$$

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

$$W = Fd = \Delta E_T$$

$$E_T = PE + KE + Q$$

$$P = \frac{W}{t} = \frac{Fd}{t} = F\bar{v}$$

k = spring constant
KE = kinetic energy
P = power
PE = potential energy
PE_s = potential energy stored in a spring
Q = internal energy
$\bar{v}$ = average velocity or average speed
W = work
x = change in spring length from the equilibrium position

Power

Rate at which work is done or energy is usec

$$P = \frac{W}{t} = \frac{Fd}{t} = Fv$$

Work/Energy Principle

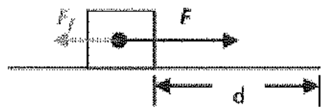
Energy is the ability to do work... Work results in a change in total energy

$W = Fd = \Delta E_T$

For work to be done – need force AND motion

Force must agree in direction with distance

Work done horizontally → Kinetic Energy (and/or Heat)

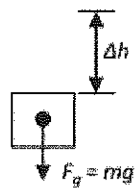


If frictionless, all work → KE

If $F = F_f$ all work → HEAT (no gain in speed)

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

Work done vertically → Gravitational Potential Energy (and/or Heat)

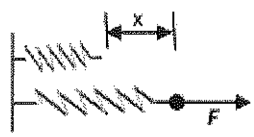


If frictionless, all work → PE

If there is a difference between PE gained and work done some work was done against friction (HEAT)

$\Delta PE = mg\Delta h$

Work done on a spring → Spring Potential Energy (and/or Heat)



If frictionless, all work → PE_S

If there is a difference between PE_S gained and work done some work was done against friction (HEAT)

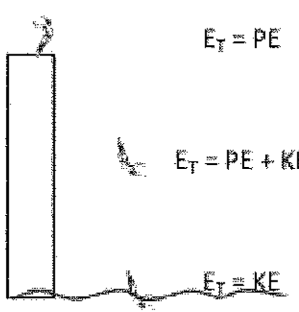
$PE_S = \frac{1}{2} kx^2$

Law of Conservation of Energy

$$E_T = PE + KE + Q$$

PE and KE are forms of mechanical energy.

Heat is non-mechanical, so frictionless systems perfectly conserve mechanical energy!



Cliff Diver – assuming no air resistance…

	E_T	PE	KE
Top	$E_T =$	PE +	0
½ pt	$E_T =$	PE +	KE
Bottom	$E_T =$	0 +	KE

E_T unchanged

$PE_{Top} = KE_{Bottom}$

Work on a spring = $F_{s\,Avg}$ (x)

Work = area of F_s vs x graph, which is a triangle so $W = 1/2F_sx$ where

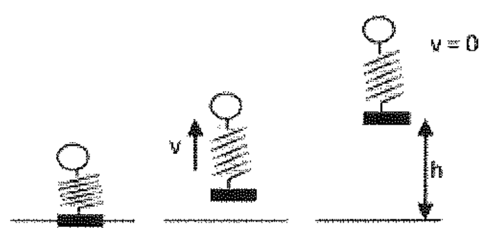
$$F_s = kx$$

So $W = 1/2(kx)x = 1/2kx^2$

$W = PE_s = 1/2kx^2$

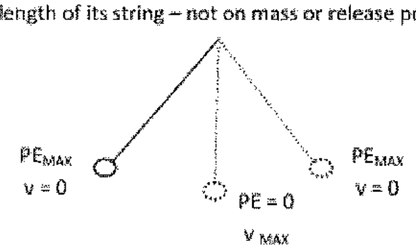
Spring Toy – if no energy is lost

$PE_S \rightarrow KE_{MAX} \rightarrow PE_{TOP}$



Pendulum

Period (time for one complete oscillation) of a pendulum depends on the length of its string – not on mass or release position

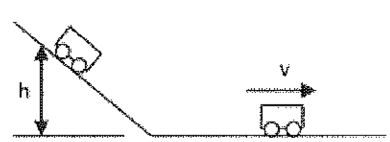


Sliding Down Slope – if frictionless...

$PE_{TOP} + KE_{TOP} = KE_{BOTTOM}$

If not frictionless...

$PE_{TOP} + KE_{TOP} = KE_{BOTTOM} + Q$ (work done by friction)



Unit 4: Vocabulary and Variables			
Term	**Variable**	**Units**	**Related Equation/Notes**
Energy (Total Energy)	E or E_T	J , $\frac{kg\,m^2}{s^2}$, Nm	
Kinetic Energy	KE	J, $\frac{kg\,m^2}{s^2}$, Nm	
Potential Energy	PE	J, $\frac{kg\,m^2}{s^2}$, Nm	
Elastic Potential Energy	PE_s	J, $\frac{kg\,m^2}{s^2}$, Nm	
Internal Energy	Q	J, $\frac{kg\,m^2}{s^2}$, Nm	
Work	W	J, $\frac{kg\,m^2}{s^2}$, Nm	
Power	P	W, $\frac{Nm}{s}$	
Spring Force	F_s	N, $\frac{kg\,m}{s^2}$	
Net Force (Average Force)	F_{net}	N, $\frac{kg\,m}{s^2}$	
Stretch of a Spring	x	m	
Height	h	m	
Initial Velocity	v_i	m/s	
Final Velocity	v_f	m/s	
Change in Velocity	Δv	m/s	
Total (mechanical) energy	E_T	J, $\frac{kg\,m^2}{s^2}$, Nm	
Spring Constant	k	N/m	
Gravitational field strength or acceleration due to gravity	g	N/kg	
Mass	m	kg	