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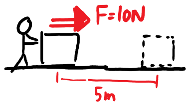
Ex1) 

$F = 10N$, 5m

$W = F_{\parallel} d = (10)(5) = 50\ J$

Unit 4: Work, Energy and Power

1 - Work

Energy: the ability to do work.

Work and energy are:

Scalar values

Measured in Joules (J)

Work can be defined as either:

A change in Energy or The product of... Force and distance

$\boxed{W = \Delta E}$ $\boxed{W = F_{\parallel} d}$

parallel

holding

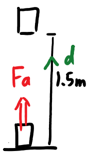
In physics we talk about work being done... on an object

Ex.

- If I hold a 30 kg weight at a height of 1.5 m, I'm using energy, therefore...
- However the work is **not** being done on the weight, it is being done on my muscles.
- *Think of it like this: though I am exerting a* force *on the weight, its* distance moved *is zero, therefore* No *work is done on it.*

Ex. If I were to lift the 30.0 kg weight up off the ground to a height of 1.5 m, how much work would be done on the weight?

$F_a = F_g = 30(9.8) = 294$



Fa, d, 1.5m

$W = F_{\parallel} d$

$= (294\ N)(1.5)$

$= \boxed{441\ J}$

When an object is lifted against gravity the formula:

W = Fd

$F_a = F_g$

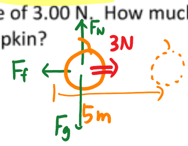
$\boxed{W = mg\Delta h}$

Where: m = mass

g = accel. due to gravity

Δh = change in height

Ex. A 10.0 kg pumpkin is moved horizontally 5.00 m at a constant velocity across a level floor using a horizontal force of 3.00 N. How much work is done in moving the pumpkin?



F_N, 3N, F_f, F_g, 5m

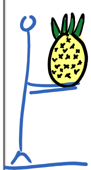
$W = F_a \times d$

$= (3N)(5m)$

$= 15$ Joules

Note: Use Applied force, not net force

Ex. A 3.0 kg pineapple is held 1.2 m above the floor for 15 s. How much work is done on the pineapple?



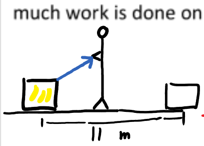
$W = F d$

zero distance moved.

$W = \varnothing$

Note: No distance means no work.

Ex. A 50.0 kg banana box is pulled 11.0 m along a level surface by a rope. If the rope makes an angle with the floor of 35° and the tension in the rope is 90.0 N, how much work is done on the box?



11 m

90N, 35°

$F_x = 90 \cos 35°$

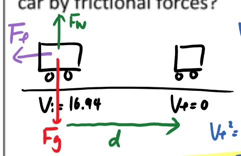
$W = F_{\parallel} d$

$W = F_x\ d$

$\boxed{Work = Fd\cos\theta} = 811\ J$

Note: Use on the Component of the force that is in the direction of displacement

Ex. A 1385 kg car traveling at 61 km/h (16.94 m/s) is brought to a stop while skidding 42 m. What is the work done on the car by frictional forces?



F_f, F_N, F_g, $V_i = 16.94$, $V_f = 0$, d

$V_f = 0$

$V_i = 16.94$

$d = 42m$

$a = ?$

$V_f^2 = V_i^2 + 2ad$

$a = -3.42\ m/s^2$

$F_{net} = F_f$

$ma = F_f$

$(1385)(-3.42) = F_f$

$F_f = -4737\ N$

$W = F_f \cdot d = -4737 \times 42m$

$= -200000$ Joules

Note: Work can be negative if the force doing the work acts in the negative direction.

V=0 $E_k = 0$

WS # 1

Kinetic

$E_k = 100J$

Fusion / Fission

Light

Energy

Gravitational Potential

Gravitational Potential

Energy

Chemical Potential

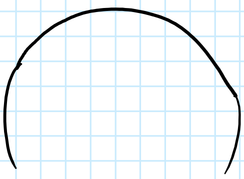
Sound

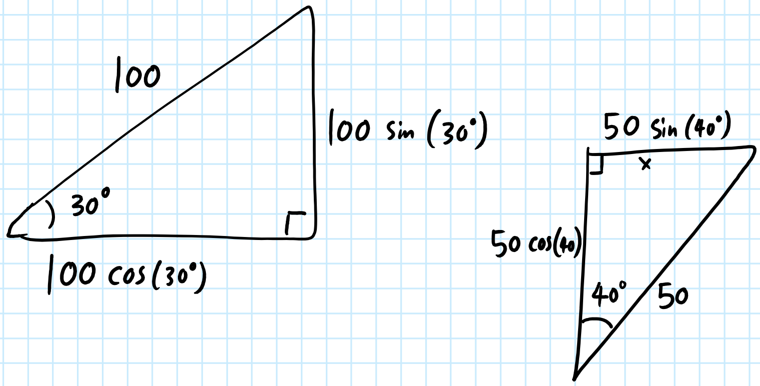
wave

Thermal / Heat

$E_p = 100\ J$

$E_p = 20\ J$





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Unit 4: Work, Energy and Power

2 – Potential Energy

Potential Energy: stored Energy.

Examples:

Chemical : food, batteries

Elastic : bungee cord, bow

electrical : static charges

- In this class we will focus on…
  gravitational Potential Energy.
- This is stored energy due to…
  an object's position (height)
- Remember:
  energy can be converted into different form by doing work.

Gravitational Potential Energy:

$$\boxed{E_p = mgh}$$

(Joules)

Where:
m = mass (kg)
g = accel. (m/s²)
h = height (m)

Gravitational energy is always measured…

relative to a reference point

↳ where is h = 0 ?

Ex. A 15.0 kg textbook is sitting on a 1.20 m tall table. If the book is lifted 0.80 m above the table, how much gravitational potential energy does it have:

a. with respect to the table?

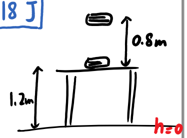
$E_p = mgh = (15kg)(9.8)(0.8m) = \boxed{118\ J}$

set h=0 on table

b. with respect to the floor?

$E_p = mgh = (15)(9.8)(2\ m)$
$= \boxed{294\ J}$

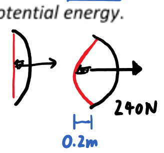
set h=0 on floor.



Ex 2. An archer pulls on a bow string with an average force of 240 N while drawing the arrow back a distance of 0.200 m. Calculate the potential energy of the bow-arrow system.

$W = F \cdot d$

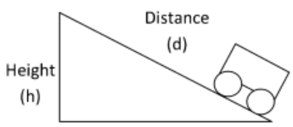
HINT: The **work** done to the bow is all being stored as *potential energy*.



$W = (240N)(0.2m)$
$= \boxed{48\ Joules}$

Ramp It Up!

Procedure: Measure the work done on a cart and its Ep at the top of the ramp.

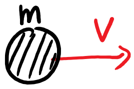


W = Fd E_p = mgh

Trial 1:		Trial 2:		Trial 3:	
F =	m =	F =	m =	F =	m =
d =	g =	d =	g =	d =	g =
	h =		h =		h =
W =	Ep =	W =	Ep =	W =	Ep =

How does the work done on the cart compare to its gain in potential energy?

Using all the words ***work, height, force*** and ***distance*** explain why ramps can be useful machines.



Unit 4: Work, Energy and Power

3 – Kinetic Energy

Kinetic Energy: Energy of Motion

- Scalar value
- Measured in Joules

$$E_k = \frac{1}{2} m v^2$$

Where:
m = mass (kg)
v = speed (m/s)
↳ no direction !!

Ex. A 60.0 kg student is running at a uniform speed of 5.70 m/s. What is the kinetic energy of the student?

$$E_k = \frac{1}{2}[60\ kg][5.7\ m/s]^2 = 974.7\ J$$

Ex. The kinetic energy of a 2.1 kg rotten tomato is 1.00×10^3 J. How fast is it moving?

$$E_k = \frac{1}{2} m v^2 \qquad V = \sqrt{\frac{2E_k}{m}} = \sqrt{\frac{2 \times (1 \times 10^3)}{2.1}} = \boxed{31\ m/s}$$

1×10^3 2.1

The Work Energy Theorem

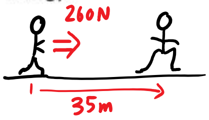
$F_{net} = ma$

- If a net force acts on an object it must be accelerating
  accel → ΔV
- This must be proportional its Change in E_k
- Therefore ∴ $F_{net} \rightarrow \Delta E_k$

$$\Delta E_k = \underbrace{F_{net} \times d}_{Work}$$

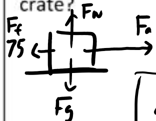
Not on Formula sheet.

Ex. A sprinter exerts a net force of 260 N over a distance of 35 m. What is his change in kinetic energy?



$$\Delta E_k = F_{net} \cdot d$$
$$= (260N)(35m)$$
$$= \boxed{9100\ J}$$

Ex. A student pushes a 25 kg crate which is initially at rest with a force of 160 N over a distance of 15 m. If there is 75 N of friction, what is the final speed of the crate?



$$F_{net} = 160 - 75 = 85N$$

$$\Delta E_k = F_{net} \cdot d$$

$$E_{kf} - \cancel{E_{ki}} = 85N\ (15m)$$

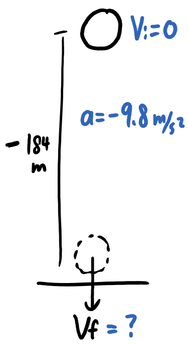
$$\frac{1}{2} m V^2 = 1275 \qquad \boxed{V = 10\ m/s}$$

Left) Quicksilver, a mutant from the comic X-men, is said to have a top speed of 4091 m/s. What is his kinetic energy? mass = 73 kg

~ 600 million J

$$E_k = 6.1 \times 10^8\ J$$

Right) In the spiderman comic, Gwen Stacy was pushed from the top of the George Washington Bridge by evil Green Goblin. What is Gwen's Kinetic Energy just before hitting the water 184 m below if her mass is 55 kg.



$$V_f^2 = V_i^2 + 2ad$$

$$E_k = \frac{1}{2} m V_f^2$$

WS # 2 / 3

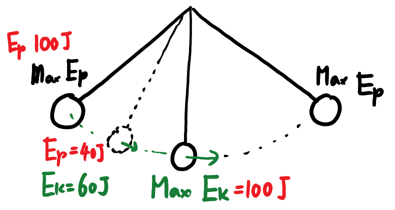
Unit 4: Work, Energy and Power

4 – The Law of Conservation of Energy

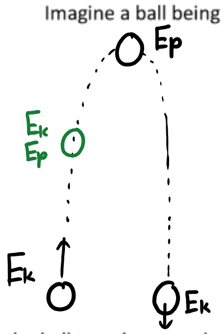
The Law of Conservation of Energy:

Energy cannot be created or destroyed, only changed from one form into another.

This is similar to a pendulum:



Imagine a ball being thrown up into the air:



As the ball travels upwards E_k is converted into E_p

As the fall falls down E_p is converted into E_k

- When only conservative forces (like gravity) work on an object... $E_k \rightarrow E_p$ $E_p \rightarrow E_k$
- When forces like friction are at work then energy is not conserved.
- Friction converts some energy into Heat

The Law of Conservation of Energy:

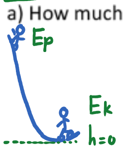
$$\text{Total } E_i = \text{Total } E_f$$

$$E_{ki} + E_{pi} = E_{kf} + E_{pf}$$

$$\frac{1}{2}mv_i^2 + mgh_i = \frac{1}{2}mv_f^2 + mgh_f$$

Ex: While jumping over The Great Wall of China an 82 kg skateboarder is needs to leave the ramp traveling at 78 km/h. → ÷3.6 = 21.67 m/s

a) How much potential energy does he need to start with?



$$\cancel{E_{ki}} + E_{pi} = E_{kf} + \cancel{E_{pf}}$$

$$E_{pi} = \frac{1}{2}mv^2 = \frac{1}{2}(82)(21.67)^2$$

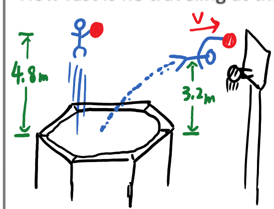
$$= \boxed{19247\text{ J}} \rightarrow 19000$$

b) What minimum height of ramp should he use?

$E_p = mgh$ $19247 = (82)(9.8)h$

$$\boxed{h = 24\text{ m}}$$

Ex: A trampoline dunk artist is bounces to a maximum vertical height of 4.8 m before launching himself towards the hoop. At the top of his arc he is 3.2 m above the ground. How fast is he traveling at this point?



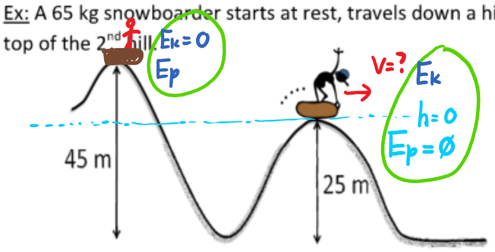
$$E_{pi} + \cancel{E_{ki}} = E_{pf} + E_{kf}$$

$$\cancel{m}gh_i = \cancel{m}gh_f + \frac{1}{2}\cancel{m}v^2$$

$$(9.8)(4.8\text{ m}) = 9.8(3.2) + \frac{1}{2}v^2$$

$$\boxed{V = 5.6\text{ m/s}}$$

Ex: A 65 kg snowboarder starts at rest, travels down a hill into a gulley and back up the other side as shown. Find his speed at top of the 2nd hill.



$$E_{pi} + \cancel{E_{ki}} = \cancel{E_{pf}} + E_{kf}$$

$$\boxed{V_f = 20\text{ m/s}}$$

HW WS # 4

Unit 4: Work, Energy and Power

5 – Power

Power is the rate (per second) of doing Work !! (J)

Power is measured in J/s or Watts (W)

$$P = \frac{Work}{t} = \frac{\Delta E}{t}$$

ΔE_k, ΔE_p, both.

Ex. Lover's Leap is a 122 m vertical climb. The record time of 4 min 25 s was achieved by Dan Osman (65 kg). What was his average power output during the climb?

122m

4m → 240 s
⇒ t = 265 s

$P = \frac{\Delta E}{t} = \frac{\Delta E_p}{t} = \frac{mgh_f}{t}$

Since he is climbing W = ΔE_p

$= \frac{65(9.8)(122m)}{265s} = \boxed{293W}$

Ex. A 1.00×10^3 kg car accelerates from rest to a velocity of 15.0 m/s in 4.00 s. Calculate the power output of the car. Ignore friction.

1000 kg

$E_k = 0$ 15 m/s

Car is speeding up ∴ gain E_k

$P = \frac{W}{t} = \frac{\Delta E_k}{t} = \frac{\frac{1}{2}mv_f^2}{4s}$ 15 m/s

$P_{output} = \boxed{28125\ W} \sim \boxed{38\ hp}$

1 hp = 745.7 Watts

Another useful formula:

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

and, $W = Fd$

Therefore: $\boxed{P_{ower} = F \cdot v}$ Constant.

not on formula sheet.

Ex. A student uses 140 N to push a block up a ramp at a constant velocity of 2.2 m/s. What is their power output?

140N 2.2 m/s

$P = F \cdot v$

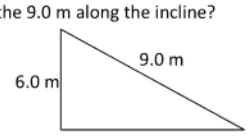
$P = 140N \cdot 2.2 m/s = 308\ W$

Note that this formula is only useful when...

Constant Velocity !!!!

Power Worksheet 4.5

1) A 45.0 kg student runs at a constant velocity up the incline shown. If the power output of the student is 1.50×10^3 W, how long does it take the student to run the 9.0 m along the incline?



2) A 20.0 kg object is lifted vertically 2.50 m in 2.00 s at a constant velocity. Calculate the power output of the student.

3) A 2.00 kg object is accelerated uniformly from rest to 3.00 m/s while moving 1.5 m across a level frictionless surface. Calculate the power output.

4) An 8.5×10^2 kg elevator is pulled up 32.0 m at a constant velocity of 1.40 m/s. Calculate the power output of the motor.

1) 1.8 s 2) 245 W 3) 9.0 W 4) 12000 W

another unit for Energy

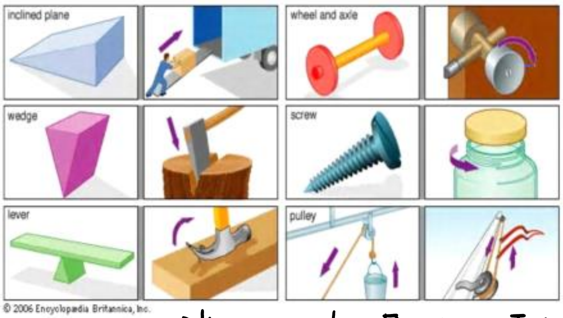
3000 mAh

Unit 4: Work, Energy and Power

6 – Efficiency

Efficiency is a measure of how much... of the Energy that goes into a machine actually gets used.

Machines are useful because they allow us to use less force over a longer distance to do the same work.



$\Delta V \rightarrow$ Kinetic $\Delta h \rightarrow$ Potential $\Delta T \rightarrow$ Heat

The 2nd Law of Thermodynamics states that whenever work is done, some energy is converted to heat.

Therefore: $W_{in} > W_{out}$

Work in: total energy supplied to a machine

Work out: amount of Energy actually used

The Efficiency of a machine is: (J)

$$\boxed{Eff = E = \frac{W_{out}}{W_{in}} \times 100\%}$$

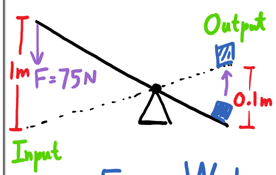
less than 100%

Watt

$$\boxed{Eff = \frac{P_{out}}{P_{in}} \times 100\%}$$

There are no units for efficiency, it is expressed as... percentage.

Ex: A lever is used to lift a 50.0 kg object 10.0 cm. To do this we must apply a force of 75 N to the end of the lever which displaces 1.00 m. Find the efficiency of the lever.



$W_{in} = F_{\parallel} d = 75\,N\,(1m) = 75\,J$

$W_{out} = \Delta E_p = mg\Delta h$
$= 50kg\,(9.8)(0.1) = 49\,J$

$Eff = \frac{W_{out}}{W_{in}} = \frac{49}{75} \times 100\% = 65\%$

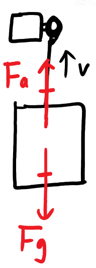
Worksheet 4.6: Efficiency

1) A 5.00 x 10² W electric motor lifts a 20.0 kg object 5.00 m in 3.50 s. What is the efficiency of the motor?

2) If a 1.00 x 10² W motor has an efficiency of 82%, how long will it take to lift a 50.0 kg object to a height of 8.00 m?

3) A 955.0 kg car is accelerates uniformly from rest to 16.0 m/s while moving 18.0 m across a level surface. If the car uses 125 000 W of power, what is the efficiency of the car?

An 8.5 x 10² kg elevator is pulled up at a constant velocity of 1.00 m/s by a 10.0 kW motor. Calculate the efficiency of the motor.



$F_{apply} = F_g = mg = (850\,kg)(9.8) = 8330\,N$

not on Formula sheet

$P = F \cdot v$

$P_{out} = F_a \cdot v = 8330\,(1\,m/s)$

$P_{out} = 8330\,W$

$P_{in} = 10\,kW = 10000\,W$

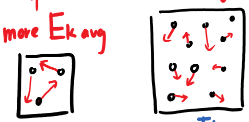
$Eff = \frac{P_{out}}{P_{in}} \times 100\% = \boxed{83.3\%}$

1) 56% 2) 48 s 3) 43%

March 2nd Thursday Energy Test !!

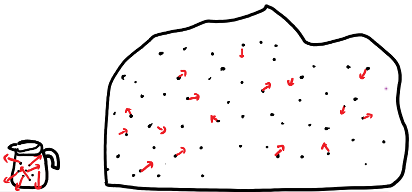
70°C
Higher Temp.
↑
more Ek avg

20°C
less Ek avg



more Thermal Energy
(more stuff !!!)

Unit 4: Work, Energy and Power
7 – Thermal Energy



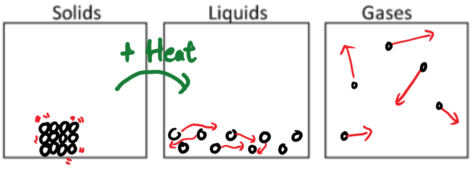
Thermal Energy vs. Temperature

Thermal energy Heat (Q): The total amount of Ek + Ep of the particles in an object.

Temperature: Average Ek of the particles in an object.

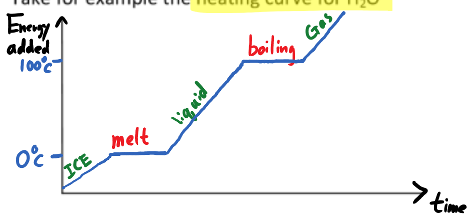
Example: which contains more heat – a pot of boiling water or an iceberg?
ICEberg
Why? So many more particles

Atoms and molecules are in constant motion:

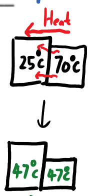


When a material is heated the molecules move faster and as a result it will (generally) expand

If an object is heated it will either (Solid → Liquid → Gas)
1) Increase Temperature 2) Change State
Take for example the heating curve for H_2O



Heat will always flow from high to Low Temperature concentration by either
1) Conduction (Contact)
2) Convection (movement of fluid) Liquid/Gas
3) Radiation (no medium required)
Until Thermal Equilibrium is achieved.
(Same temperature)

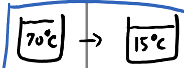


The amount of heat transferred to an object is found with:

$$Q = mc\Delta T$$

ΔT ← $T_f - T_i$

If Q is +, Energy added
Q is –, Energy removed.



Where:
Q = Heat (J)
m = mass (kg)
c = Specific Heat Capacity (J/kg°C)
ΔT = Change in Temperature (°C)

Amount of Energy needed to raise the Temperature of 1 kg by 1°C

Specific Heat Capacity	
Water	4186
Carbon	720
Iron	425
Copper	387
Lead	128

Example:
Mr. Trask makes a cup of coffee by boiling 250 g of water that is initially at 15° C. How much heat is needed?

250 g → 0.25 kg

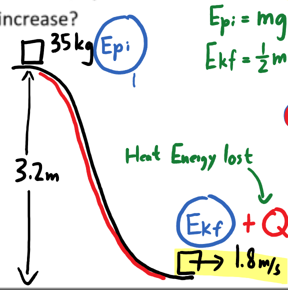
$\Delta T = T_f - T_i = 100°C - 15°C$

$Q = mc\Delta T$

$= (0.25\,kg)(4186)[85°C]$ + inc

$= \boxed{88950\ J}$

Example:
A 35 kg child goes down a 3.2 m high slide. The child is initially at rest and moving at 1.8 m/s at the bottom of the slide. If the slide is made of 12 kg of iron and all the heat is transferred into the slide, by how much does the temperature of the slide increase?



$E_{pi} = mgh = 35(9)(3.2) = \boxed{1097.6\ J}$

$E_{kf} = \frac{1}{2}mv^2 = \frac{1}{2}(35)(1.8)^2 = \boxed{56.7\ J}$

$Q = 1097.6 - 56.7$

$Q = 1040.9\ J$

$Q = mc\Delta T$

$1040.9 = (12\,kg)(425)\Delta T$

$\Delta T = +0.2°C$

Ws # 7

Work, Energy and Power

8 – Conservation of Heat and Latent Heat

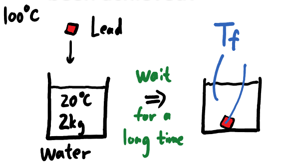
Conservation of Heat (p.237-239)

When heat is transferred from one substance to another, all of the energy transferred is conserved. In an ideal situation, we can write that the Heat Energy lost by one substance is equal to the Heat Energy ↑ Gain by the other

$$\Delta Q_{gain} = \Delta Q_{loss}$$

$$Q_{lost} + Q_{gain} = \emptyset$$

a) A 0.05 kg block of lead, at 100°C, is placed in 2 kg of water at a temperature of 20°C. What is the final temperature of the mixture when equilibrium has been achieved?



Lead, water

$$Q_{lost} + Q_{gain} = 0$$

	T_i	T_f
Lead	100°C	?
Water	20°C	?

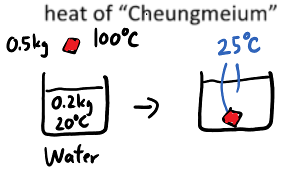
$$m_L c_L \Delta T_L + m_w c_w \Delta T_w = \emptyset$$

$$(0.05kg)(128)(T_f - 100°C) + (2kg)(4186)[T_f - 20] = \emptyset$$

$$6.4T_f - 640 + 8372T_f - 167440 = \emptyset$$

$$T_f = 20.06\ °C$$

b) 0.5 kg of a mysterious metal "Cheungmeium" at 100°C is placed in 0.2 kg of water at 20°C. The final temperature of the system is 25°C. Find the specific heat of "Cheungmeium"



Cheung, Water

$$Q_{lost} + Q_{gain} = \emptyset$$

$$m_c c \Delta T_c + m_w c_w \Delta T_w = 0$$

$$(0.5kg) \cdot C \cdot (\overset{f}{25} - \overset{i}{100}) + (0.2kg)(4186)(\overset{f}{25} - \overset{i}{20}) = \emptyset$$

$$\therefore \boxed{C = 111.6\ J/kg°C}$$

Change of State and Latent Heat

Latent heat: the amount of heat (energy) required to change the phase of a unit mass of a substance.

$$\boxed{Q = mL_f} \quad or \quad \boxed{Q = mL_v}$$

"L" Latent Heat, measure in Energy/Mass, [J/kg].

Heat (energy) is required to melt a substance (solid to liquid phase transition). The corresponding latent heat is called the *latent heat of fusion*. L_f When a substance solidifies, it releases heat.

Heat (energy) is required to vaporize a substance (liquid to gas phase transition). The corresponding latent heat is called the *latent heat of vaporization*. L_v A substance releases heat when it condenses into liquid.

Table 14.2 Heats of Fusion and Vaporization [4]

		L_f			L_v	
Substance	**Melting point (°C)**	**kJ/kg**	**kcal/kg**	**Boiling point (°C)**	**kJ/kg**	**kcal/kg**
Helium	−269.7	5.23	1.25	−268.9	20.9	4.99
Hydrogen	−259.3	58.6	14.0	−252.9	452	108
Nitrogen	−210.0	25.5	6.09	−195.8	201	48.0
Oxygen	−218.8	13.8	3.30	−183.0	213	50.9
Ethanol	−114	104	24.9	78.3	854	204
Ammonia	−75		108	−33.4	1370	327
Mercury	−38.9	11.8	2.82	357	272	65.0
Water	0.00	334	79.8	100.0	2256[5]	539[6]
Sulfur	119	38.1	9.10	444.6	326	77.9
Lead	327	24.5	5.85	1750	871	208
Antimony	631	165	39.4	1440	561	134
Aluminum	660	380	90	2450	11400	2720
Silver	961	88.3	21.1	2193	2336	558
Gold	1063	64.5	15.4	2660	1578	377
Copper	1083	134	32.0	2595	5069	1211
Uranium	1133	84	20	3900	1900	454
Tungsten	3410	184	44	5900	4810	1150

$Q = m\boxed{c}\Delta T$ for Temperature change!!

$Q = m\boxed{L_f}$
$Q = m\boxed{L_v}$] for phase change

−20°C Ice → 20° Water.

① −20°C Ice → 0°C Ice — Temp change!!
② 0°C Ice → 0°C Water — phase change!!
③ 0°C Water → 20°C Water — Temp. change!!

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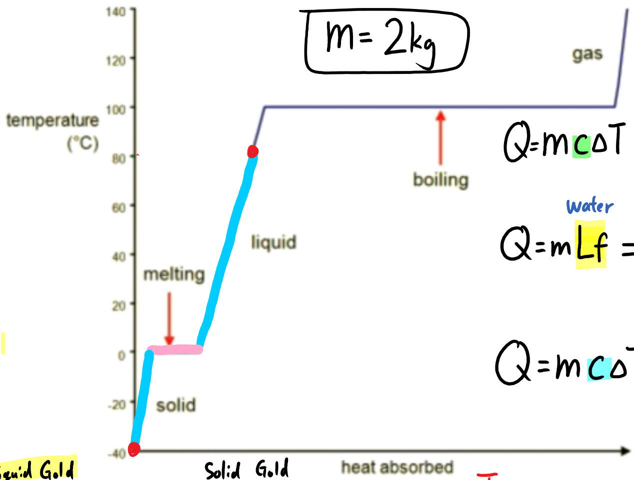
Heating curve of water

As we heat a block of ice, the temperature rises ($Q = mc\Delta T$) until it reaches its melting point. At certain fixed point on the temperature scale (melting point, boiling point) the additional heat energy des not increase the temperature; instead, a change of state occurs. The temperature remains constant during the state change because the energy is being used to weaken or breaks the intermolecular bonds

$\boxed{m = 2kg}$



Example: A block of ice at -40°C is heated to liquid water at 80° in the following steps

Step 1: -40°C Ice to 0°C Ice (T_i, T_f)

$Q = mc\Delta T = (2kg)(2090)(0-(-40)) = 167{,}200\,J$

$L_f \rightarrow$ Liquid

Step 2: 0°C Ice to 0°C Water

$Q = mL_f = (2kg)(334000\ J/kg) = 668{,}000\,J$ (water)

Step 3: 0°C Water to 80°C Water

$Q = mc\Delta T = (2kg)(4186)[80-0] = 669760\,J$

Total Energy $= \boxed{1.5\times10^6\ J}$

$\$0.08 / 3.6\times10^6\ J$

Liquid Gold $C = 150\ J/kg\,°C$

Solid Gold $C = 129\ J/kg\,°C$

melt pt 1063°C

Ex 1) How much heat energy is required to melt 2.0 kg of solid gold at [illegible]45°C to liquid gold at 1645°C?

① $Q = mc\Delta T = (2kg)(129)[1063-45] = 262{,}644\,J$

② $Q = mL_f = (2kg)(64.5\times10^3) = 129{,}000\,J$

③ $Q = mc\Delta T = (2)(150)[1645-1063] = 174{,}600\,J$

$\boxed{5.7\times10^5\ J}$

Try

Ex 2) How much heat energy is needed to boil 3 kg of water at 25°C to steam.

① 25°C Water → 100°C water

$Q = mc\Delta T = (3kg)(4186)(100-25) = 941{,}850\,J$

② 100°C Water → 100°C steam

$Q = mL_v = (3kg)(2256000\ J/kg) = 6{,}768{,}000\,J$

$\boxed{7.7\times10^6\ J}$

Ex 3) How much heat does a refrigerator freezer have to remove from 1.5 kg of water at 20°C to make ice at -10°C

① 20°C Water → 0°C Water $Q = mc_w\Delta T = (1.5kg)[4186][0-20] = -125{,}580\,J$

② 0°C water → 0°C Ice $Q = mL_f = (1.5kg)(334000\ J/kg) = -501{,}000\,J$ (fusion) Remove Energy to Freeze

③ 0°C Ice → -10°C Ice $Q = mc_I\Delta T = (1.5kg)[2090][-10-0] = -31{,}350\,J$

∴ Total Heat removed (−) : $\boxed{6.58\times10^5\ J}$

p.240 Q2-5 p.244 Q1-5

Worksheet 4.1: **Work**

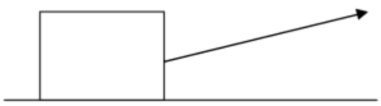
1. A 20.0 N pomegranate is lifted at a constant velocity from the floor to a height of 1.50 m. How much work is done on the object?

2. A 15.0 N potato is moved horizontally 3.00 m across a level floor using a horizontal force of 6.00 N. How much work is done on the potato?

3. A 2.20 N pear is held 2.20 m above the floor for 10.0 s. How much work is done on the pear?

4. A 10.0 kg pink grapefruit is accelerated horizontally from rest to a velocity of 11.0 m/s in 5.00 s by a horizontal force. How much work is done on the pink grapefruit assuming no friction?

5.



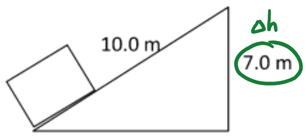
A 90.0 N box of papayas is pulled 10.0 m along a level surface by a rope. If the rope makes an angle of 20.0° with the surface, and the force in the rope is 75.0 N, how much work is done on the box?

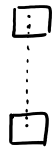
6. A 60.0 kg student runs at a constant velocity up a flight of stairs. If the height of the stairs is 3.2 m, what is the work done against gravity?

7. A 20.0 kg passionfruit is pulled horizontally 9.0 m along a level frictionless surface at a constant velocity. How much work is done on the passionfruit?

$W = mg\Delta h$

8.





An 80.0 kg pumpkin is pushed up at a constant velocity along a frictionless incline as shown in the diagram. How much work is done on the pumpkin in moving it up the incline?

$W = (80\,kg)(9.8)(7\,m) = \boxed{5488\ J}$

9. A 25.0 kg pickle is accelerated from rest through a distance of 6.0 m in 4.0 s across a level floor. If the friction force between the pickle and the floor is 3.8 N, what is the work done to move the object?

10. A 1165 kg car traveling at 55 km/h is brought to a stop while skidding 38 m. Calculate the work done on the car by the friction forces.

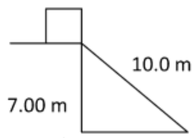
1) 30.0 J 2) 18.0 J 3) 0 J 4) 605 J 5) 705 J 6) 1900 J 7) 0 J 8) 5500 J 9) 135 J 10) 1.4×10^{5} J

Worksheet 4.2 - Potential Energy

1. A 25.0 N object is held 2.10 m above the ground. What is the potential energy with respect to the ground?

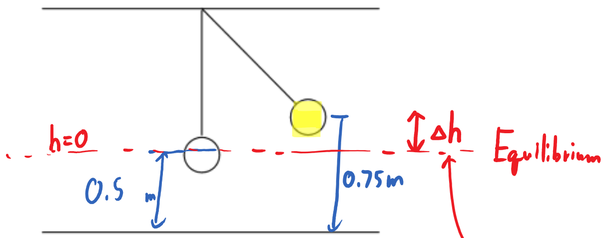
2. An uncompressed spring is 20.0 cm in length. What is the potential energy of the spring when an average force of 65.0 N compresses it to a length of 13.5 cm?

3.



A 2.75 kg box is at the top of a frictionless incline as shown in the diagram. What is the potential energy with respect to the bottom of the incline?

4.

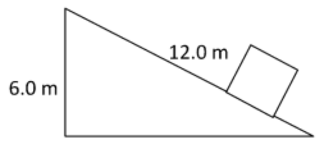


The bob of a pendulum has a mass of 2.0 kg and hangs 0.50 m above the floor. The bob is pulled sideways so that it is 0.75 m above the floor. What is its potential energy with respect to its equilibrium position?

$$E_p = mgh = 2\,kg\,(9.8\,m/s^2)(0.25\,m)$$

$$\boxed{E_p = 4.9\,J}$$

5.



A 2.00 x10^3 kg crate is pushed to the top of an incline as shown. If the force applied along the incline is 12000 N, what is the potential energy of the object when it is at the top of the incline with respect to the bottom?
(Ok smartypants how much energy was wasted as heat?)

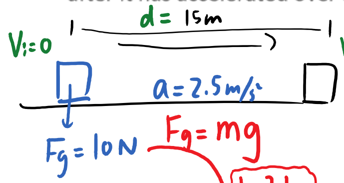
1) 52.5 J 2) 4.23 J 3) 189 J 4) 4.9 J 5) 1.18x10^5 J (26000 J)

Worksheet 4.3 - Kinetic Energy

1. A 3.0 kg ewok is traveling at a constant speed of 7.5 m/s. What is its kinetic energy?

2. The kinetic energy of a 20.0 N droid is 5.00×10^2 J. What is the speed of the droid?

3. A 10.0 N lightsaber is accelerated from rest at a rate of 2.5 m/s^2. What is the kinetic energy of the lightsaber after it has accelerated over a distance of 15.0 m.



$V_f^2 = V_i^2 + 2ad$

$V_f^2 = 0 + 2(2.5)(15)$

$V_f = 8.66$ m/s

$F_g = mg$

$\boxed{1.02\ kg}$

$$E_k = \frac{1}{2} m v^2 = \frac{1}{2}(1.02\ kg)(8.66)^2 = \boxed{38\ J}$$

4. A 1200.0 N Wookie jumps off a cliff on Earth. What is its kinetic energy after it falls for 4.50 s?

5. An 8.0 kg bantha poodoo is dropped from a height of 7.0 m. What is the kinetic energy of the poodoo just before it hits the ground? (No kinematics!)

6. A 9.00 kg object falls off of a 1.2 m high table. If all of the objects potential energy is converted into kinetic energy just before it hits the floor, how fast is it moving? (Solve without using kinematics)

7. Solve #6 using kinematics this time. Is there any difference?

8. A golfer wishes to improve his driving distance. Which would have more effect:
(a) *doubling the mass* of his golf club or
(b) *doubling the speed* with which the clubhead strikes the ball?
Explain your answer.

1) 84 J 2) 22.1 m/s 3) 38 J 4) 119 000 J 5) 550 J 6) 4.8 m/s 7) 4.8 m/s (down) 8) b

Worksheet 4.4 -Law of Conservation of Energy .

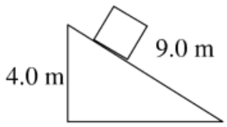
1. Physics student is dropped (don't ask why or you're next). If they reach the floor at a speed of 3.2 m/s, from what height did they fall?

2. A heavy object is dropped from a vertical height of 8.0 m. What is its speed when it hits the ground?

3. A bowling ball is dropped from the top of a building. If it hits the ground with a speed of 37.0 m/s, how tall was the building?

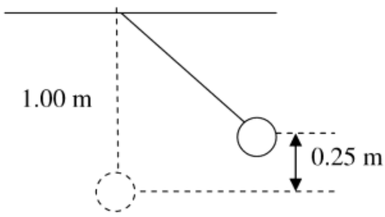
4. A safe is hurled down from the top of a 1.3 x 10^2 m building at a speed of 11.0 m/s. What is its velocity as it hits the ground?

5.



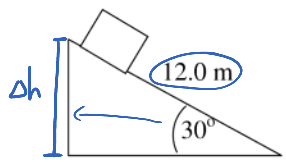
A box slides down a frictionless ramp. If it starts at rest, what is its speed at the bottom?

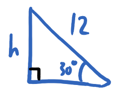
6.



A pendulum is dropped from the position shown, 0.25 m above its equilibrium position. What is the speed of the pendulum bob as it passes through its equilibrium position? B

7.



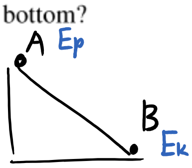


$\sin 30 = \frac{h}{12}$

$h = 12 \cdot \sin 30$

$h = 6$

A box slides down a frictionless incline as shown. If the box starts from rest, what is its speed at the bottom?



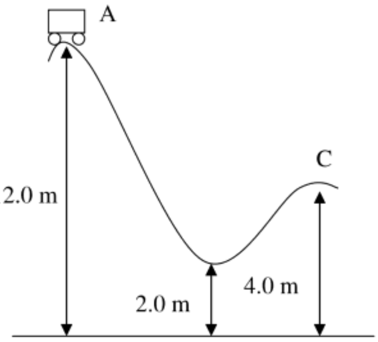
$E_{pi} = E_{kf}$

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

$9.8(6m) = \frac{1}{2}v^2$

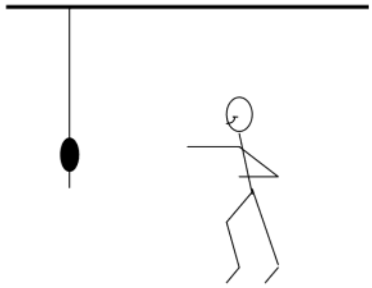
$\boxed{V = 10.8\ m/s}$

8.



A roller coaster car starts from rest at point A. What is its speed at point C if the track is frictionless?

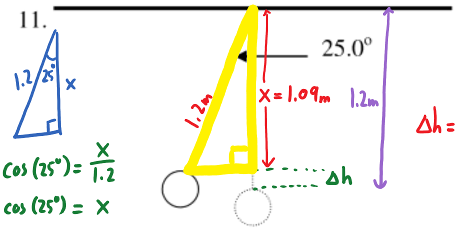
10.



An 80.0 kg student running at 3.5 m/s grabs a rope that is hanging vertically. How high will the student swing?

9. A 2.5 kg object is dropped from a height of 10.0 m above the ground. Calculate the speed of the object as it hits the ground.

11.



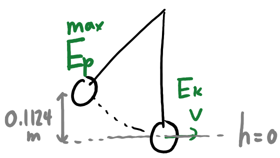
$\Delta E_p = mg\Delta h$

$\Delta h = 0.1124\ m$

$\cos(25°) = \frac{x}{1.2}$

$1.2\cos(25°) = x$

A pendulum is 1.20 m long. If the pendulum is pulled until it makes a 25.0° angle to the vertical, what is the speed of the pendulum bob when it passes through its equilibrium position? HINT: Determine the vertical drop of the pendulum bob first.



$E_{pi} + \cancel{E_{ki}}^{0} = \cancel{E_{pf}}^{0} + E_{kf}$

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

$(g)(0.1124\ m) = \frac{1}{2}(v)^2$

$\boxed{v_{max} = 1.48\ m/s}$

Quiz next class on 4.1 – 4.4

Work / Ek / Ep / Conservation.

1) 0.52 m 2) 13 m/s 3) 69.8 m 4) 52 m/s 5) 8.9 m/s 6) 2.2 m/s 7) 10.8 m/s 8) 13 m/s 9) 14 m/s 10) 0.63 m 11) 1.49 m/s

Worksheet 4.7: Thermal Energy, Heat and Specific Heat Capacity

1. How much heat is needed to rise the temperature of 462 g of water from 24.0 °C to 80.0 °C?

$\boxed{108\,000\ J}$

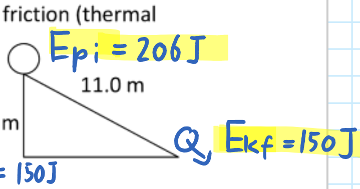
2. How much heat is required to raise the temperature of 462 g of copper from 24.0 °C to 80.0 °C?

$\boxed{10\,100\ J}$

3. A 0.240 kg chunk of carbon is heated to 215 °C and quickly placed into 0.275 kg of water that has a temperature of 12 °C. What will the final temperature of the water be?

$T_f = \boxed{39°C}$

4. A 3.0 kg ball rolls down from the top of a ramp as shown. If the ball is moving at 10.0 m/sat the bottom, how much energy was lost due to friction (thermal energy)?



$E_{pi} = \overset{(3)}{m}\overset{g}{g}\overset{(7)}{h} = 205.8\ J$

$E_{kf} = \frac{1}{2}mv^2 = \frac{1}{2}(3)(10\ m/s)^2 = 150\ J$

heat

$E_{pi} = E_{kf} + \boxed{Q}$

$206\ J = 150\ J + Q$ $\boxed{Q = 56\ J}$

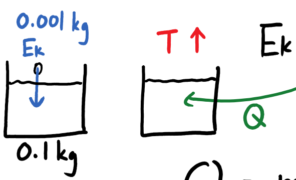
$\boxed{56\ J}$

5. A 1.00 g raindrop traveling at 40.0 m/s strikes the surface of 100 g of water in a glass. How much will the water's temperature change if we assume that:

i) all of the raindrop's kinetic energy is transformed into thermal energy, and

ii) the raindrop and the glass of water's temperatures are initially the same

$E_k = \frac{1}{2}mv^2 = \frac{1}{2}(0.001)(40)^2$



$E_k = 0.8\ J$

4186 J/kg°C

$Q = m c_w \Delta T$

$0.8\ J = [0.101\ kg](4186)\Delta T$

$\boxed{\Delta T = 0.0019\ °C}$