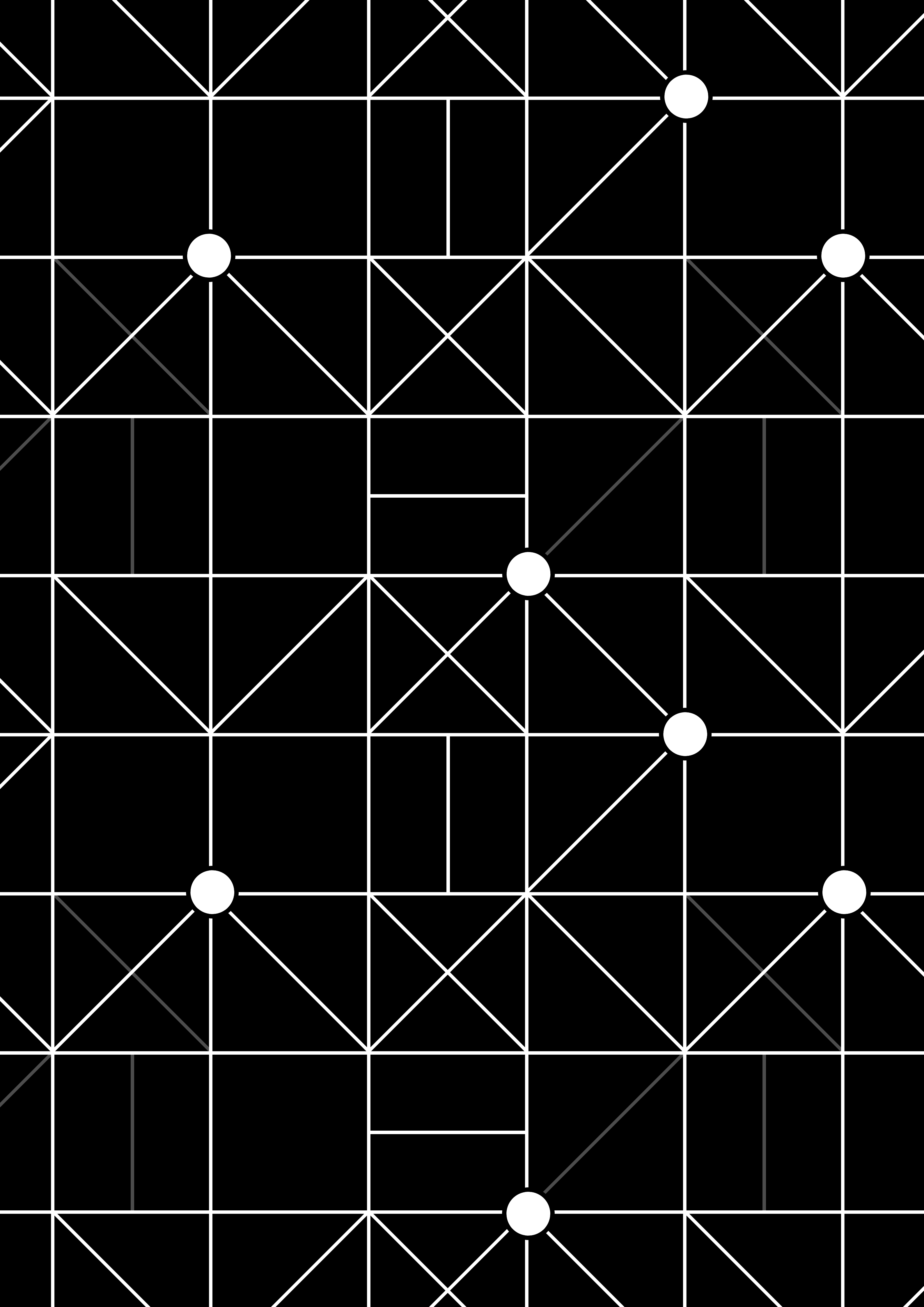


Student Notes 3 VWO Energy

Important Rule: Energy can not be created nor destroyed.

$$E_{begin} = E_{end}$$

Potential → Example:
- height
- Battery

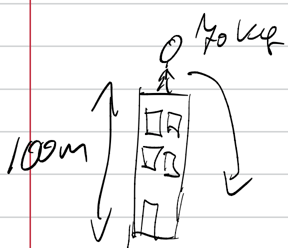
Transformed energy → Example:
- warmth (Due to Friction)

Gravitational potential Energy (E_g)

Gravitational force $F_g = m \cdot g \rightarrow [N] = [kg] \cdot [m/s^2]$

$E_g = m \cdot g \cdot h \rightarrow [J] = [kg] \cdot [m/s^2] \cdot [m]$

E_g = Gravitational energy [J]
m = mass [kg]
g = gravitational acceleration constant [m/s^2]
h = height [m]



How much is the potentical energy?

$E_g = ?$
$m = 70\,kg$
$g = 9{,}81\,m/s^2$
$h = 100\,m$

$E_g = m \cdot g \cdot h$
$E_g = 70 \cdot 9{,}81 \cdot 100 = 68670\,J$

How much is the potentical energy at the end?
This means at the ground
$h = 0\,m$
$E_g = m \cdot g \cdot h = 70 \cdot 9{,}81 \cdot 0 = 0\,J$

The potential energy Fully transformed into Kinetic energy (Movement)

A person is standing on top of a building of 120m tall. The energy that the person potentially can have is 7000 J. Calculate the mass of the person.

$E_g = 7000\ J$
$m = $
$g = 9{,}81\ m/s^2$
$h = 120\ m$

$E_g = m \cdot g \cdot h$

$m = \frac{E_g}{g \cdot h}$

$m = \frac{7000}{(9{,}81 \cdot 120)} = 5{,}946\ kg$

$m = 5{,}95\ kg$

1:
$E_g = m \cdot g \cdot h$
$\frac{E_g}{g \cdot h} = m$

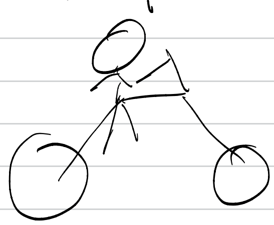
2:
$\frac{E_g}{g \cdot h} = \frac{m \cdot g \cdot h}{g \cdot h}$
$\frac{E_g}{g \cdot h} = m$

Ebegin = Eend

- Potential → Gravitational potential Energy
- Transformed → "Movement" Kinetic Energy + Heat Energy

Kinetic

Kinetic Energy: The energy that we need to make a movement possible



Morning → Cycling   Travel Distance

Eat → Musle Force → acceleration → Velocity

Eating is generating potential energy.
Cycling is using that potential energy and transforming into kinetic energy.

$$E_{kin} = \frac{1}{2}mv^2$$

You need to have potential energy before you can have kinetic energy!

E_{kin} = kinetic energy (J)
m = mass in (kg)
v = Velocity in (m/s)

If you're calculating the kinetic energy with this formula without the potential energy, then you know how many energy you need to make the movement possible. Therefore how many potential energy you need at the start

In this case:

$$E_{kin} = E_{z}$$ (Only if there is no heat loss)

a) A car is moving at 100 km/h. The car it's mass is 810 kg. What is the ammount of kinetic energy this car needs?

b) How much potential energy does this motor need to be able to deliver?

c) Rewrite the formula for kinetic energy to the "m" and the "v"

$E_{kin} = \frac{1}{2}mv^2$ m = ?
v = ?

d) Control your Rewritten formula's with the known givens

Answers:

a.) $V = 100\ km/h = 27,8\ m/s$

$m = 810\ kg$

$E_{kin} = ?$

$km/h \xrightarrow{:3,6} m/s$, $m/s \xrightarrow{x\,3,6} km/h$

$E_{kin} = \frac{1}{2} \cdot m \cdot v^2$

$E_{kin} = \frac{1}{2} \cdot 810 \cdot 27,8^2 = 313000,2\ J$

b.) $E_{kin} = E_{pot}$

The kinetic energy needs to be the same potential energy.

c.) $E_{kin} = \frac{1}{2} m v^2$

$E_{kin} = \frac{m \cdot V^2}{2} \rightarrow E_{kin} = \frac{1}{2} \cdot \frac{m \cdot v^2}{1}$

(1)

$\frac{E_{kin} \cdot 2}{v^2} = \frac{m \cdot v^2}{v^2}$

$\frac{E_{kin} \cdot 2}{v^2} = m$

(2)

$E_{kin} \cdot 2 = m \cdot v^2$

$\frac{E_{kin} \cdot 2}{v^2} = m$

$V = ?$

$E_{kin} = \frac{1}{2} m v^2$

$E_{kin} = \frac{m v^2}{2}$

$E_{kin} \cdot 2 = m v^2$

$\frac{E_{kin} \cdot 2}{m} = v^2 \rightarrow V = \sqrt{\frac{E_{kin} \cdot 2}{m}}$

Heat:

This is most of the times the "lost" energy
It's only usefull for a system like a
Heater

$$Q = F_F \cdot x$$

Q = Heat in (J)
F_F = Friction force in (N)
x = Distance in (m)

Heat is a form of Energy and it is a product of energy transformation.

Efficiency:

If there is no Heat loss the energy transformation is 100%. The energy is fully transformed into a different form of energy.

For example:

$$E_{pot} = E_{kin}$$

If there is Heat loss the energy is not fully transformed into the wanted energy form. Most of the times into Heat

For example:

$$E_{pot} = E_{kin} + Q$$ same → $$E_{begin} = E_{end}$$

10 = 8 + 2
10 = 6 + 4

Homework:
Questions 1-7 from 3.1
Page 78

The Formula for efficiency is:

$$\eta = \frac{E_{usefull}}{E_{tot}} \times 100\%$$

$\frac{J}{J}$ = (Geen eenheid)

η = The efficiency in (%)
$E_{usefull}$ = The usefull energy in (J)
E_{tot} = The total amount of energy in (J)

You always want to have the highest amount of efficiency!

Chemical Energy:

$$E_{pot} = E_{end}$$

↓

$$E_{beg} = E_{end}$$

If we take the human body as an example

$$E_{chem} = E_{kin} + Q$$

Echem is the chemical energy, the energy that's been received due to a chemical reaction.

If we eat, we get chemical energy, this is also potential energy.

This process also happens in a car engine.

Work:

If you need to apply a force you'll need energy. That energy is called work

$$E = W$$

↙ Energy ↘ Work

We use work to rewrite Forces to Energy and Energy to Force

$$W = F \cdot x$$

W = work in (J)
F = Force in (N)
x = Distance in (m)

For example:

$$E_{pot} = W$$

$$m \cdot g \cdot h = F \cdot x$$

Homework:
Questions 18, 19, 20
page 85
(Skip 18b)

Heat specific constant:

We already know that Heat is a form of Energy but the absorbtion can be a property of a substance.

The more or less energy that it takes to increase the temperature of the substances, that is called the "Heat specific constant"

$$\boxed{Q = c \cdot m \cdot \Delta T}$$

$$\Delta T = T_e - T_b$$

Q = Heat Energy in (J)
c = Heat specifik constant in (J/kg · °C)
m = Mass in (kg)
ΔT = Temperature in (°C)

Kelvin:

+100 ↓ 0°C → 273,15 K) +100
100°C → 373,15 K

100 − 0 = 100

373,15 − 273,15 = 100

You don't have to learn the heat specifik constants of substances out of your head. These are given.

$$\boxed{c = \frac{Q}{m \cdot \Delta T}} \quad \text{or} \quad \boxed{m = \frac{Q}{c \cdot \Delta T}} \quad \text{or} \quad \boxed{\Delta T = \frac{Q}{m \cdot c}}$$

Homework: Questions 21 − 27 of page 90

Questions:

1.) A car of 1,200 Kg is traveling with a velocity of 20 m/s.

a) Calculate the kinetic energy that this car needs.

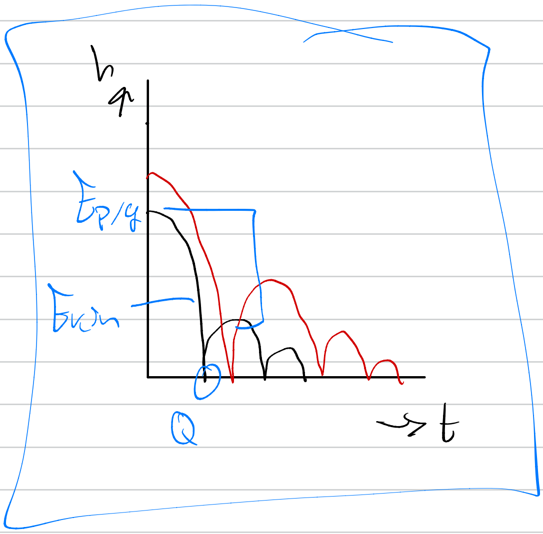
b) The person in the car sees a stopsign. How much work must be done by the brakes to stop the car?

c) The stopping distance is 30 m, how much brake force was necessary?

d) The chemical energy of the car was 400 kJ, the other Energy was transformed into Heat. Calculate the amount of generated Heat Energy.

e) How efficient is this car?

F) What can the manufacturer do, to make the car more efficiently?



Epg	Ekin	Q
100	0	
80	20	
80	20	0

$E_{pg} = E_{kin}$

$m \cdot g \cdot h = \frac{1}{2} \cdot m \cdot v^2$

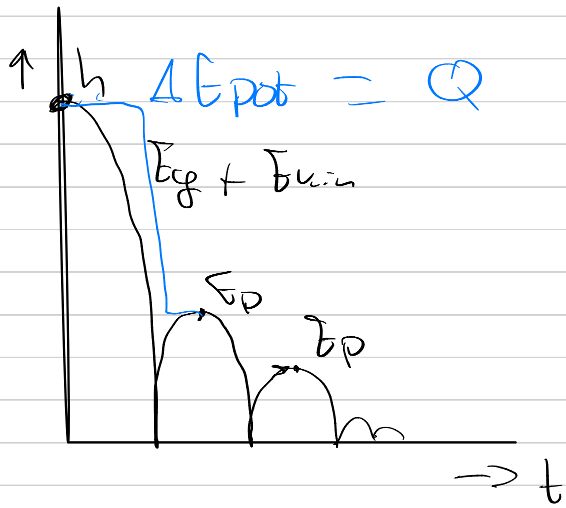
① ②

$E_{beg} = E_{end}$

$E_{pot} = E_{trans.}$

① $E_g = E_{kin} + Q$ } During the movement

② $E_g = Q$ } Then the ball stops



$E_g = E_{kin} + Q$

$Q = E_{g_1} - E_{g_2}$

$Q = m_1 \cdot g_1 \cdot h_1 - m_2 \cdot g_2 \cdot h_2$

Recap:

$$E_{beg} = E_{end}$$

Energy can't be created nor destroyed
But, it can be transformed into a specific form of energy.

$$E_{pot} = E_{transformed}$$

$E_{potential}$: The total amount of energy a system can have / deliver.

2 Forms:

1.) **Gravitational Energy:** Energy that you can deliver from a height or you need to reach that height.

2.) **Chemical Energy:** Energy that's been received because of a combustion reaction

$E_{transformed}$: The total amount of energy that's been transformed in a certain energy form.

2 Forms:

1.) **Kinetic Energy:** The amount of energy that we need for a certain motion

2.) **Heat Energy:** The total amount of energy created by friction, Impact or "lost" energy.

How is the energy transformed?

$$E_{beg} = E_{end}$$

$$E_{pot} = E_{transformed}$$

Same in each question

$$E_g = E_{kin} + Q$$

$$m \cdot g \cdot h = \frac{1}{2} m v^2 + Q$$

$$m \cdot g \cdot h = \frac{1}{2} m v^2 + F_F \cdot x$$

$$m \cdot g \cdot h = \frac{1}{2} m v^2 + Q$$

$$g \cdot h = \frac{1}{2} v^2 + Q$$

$$g \cdot h = \frac{v^2}{2} + Q$$

$$2 \cdot g \cdot h = v^2 + Q$$

$$\frac{2 \cdot g \cdot h}{v^2} = Q$$

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

$$3 = \frac{6}{2}$$

$$3 \cdot 2 = 6$$

Homework: Rewrite h and v

Efficiency: How efficient is a system?

In a perfect world we have a 100% efficiency you can achieve this if there is no energy loss.

Formula: $\eta = \frac{E_{usefull}}{E_{total}} \cdot 100\% \rightarrow$

$$E_g = E_{kin} + Q$$

$$\eta = \frac{E_{kin}}{E_g} \cdot 100\%$$

Work: The amount of Energy you need to deliver a force over a distance

$$E \rightarrow F \rightarrow a \rightarrow v \rightarrow x$$

Formula: $W = F \cdot x$

$[J] = [N] \cdot [m]$

Convert Energy to work and work to energy

$E = W$

$[J] = [J]$

Heat specific coefficient: How much energy we need to increase 1 kg of a substance 1°C.

$$Q = c \cdot m \cdot \Delta T$$

Q = Heat Energy in [J]
c = Heat specific coefficient in [J/kg·°C]
m = mass in [kg]
ΔT = Temperature in [°C] or [K]

The c is different for each substance, therefore it's a propertie of a substance.

How much energy do we need to heat up 2 kg of water to it's boiling point? The HSC is 4,18 J/kg·°C
We start at room temperature.

Answer:

$$Q = c \cdot m \cdot \Delta T$$

$c = 4{,}16 \text{ J/kg} \cdot °C$
$m = 2 \text{ kg}$
$\Delta T = 100 - 20 = 80°C$

$$Q = 4{,}16 \cdot 2 \cdot 80 = 665{,}6 \text{ J}$$

$$\boxed{Q = c \cdot m \cdot \Delta T}$$

Rewrite this formula for c, m, and T

C:

$$\frac{Q}{m \cdot \Delta T} = \frac{c \cdot \cancel{m \cdot \Delta T}}{\cancel{m \cdot \Delta T}} \qquad (1)$$

$$\frac{Q}{m \cdot \Delta T} = c$$

$$Q = c \cdot m \cdot \Delta T \qquad (2)$$

$$\frac{Q}{m \cdot \Delta T} = c$$

m:

$$Q = c \cdot m \cdot \Delta T$$

$$m = \frac{Q}{c \cdot \Delta T}$$

ΔT

$$Q = c \cdot m \cdot \Delta T$$

$$\Delta T = \frac{Q}{c \cdot m}$$

$$E_g = E_{kin} + Q$$

$$m \cdot g \cdot h = \frac{1}{2} m v^2 + Q$$

Rewrite for h, v and Q

Q:

$$m \cdot g \cdot h = \frac{1}{2} m v^2 + Q$$

$$g \cdot h = \frac{1}{2} v^2 + Q$$

$$g h = \frac{v^2}{2} + Q$$

$$2 \cdot g \cdot h = v^2 + Q$$

$$2 \cdot g \cdot h - v^2 = Q$$

h:

$$m \cdot g \cdot h = \frac{1}{2} m v^2 + Q$$

$$g \cdot h = \frac{1}{2} v^2 + Q$$

$$g \cdot h = \frac{v^2}{2} + Q$$

$$h = \frac{v^2}{2} + Q$$

$$h = \frac{0{,}5 v^2 + Q}{g}$$

v:

$$m \cdot g \cdot h = \frac{1}{2} m v^2 + Q$$

$$g \cdot h = \frac{1}{2} v^2 + Q$$

$$g \cdot h = \frac{v^2}{2} + Q$$

$$2 \cdot g h = v^2 + Q$$

$$2 \cdot g \cdot h - Q = v^2$$

$$\sqrt{2 \cdot g \cdot h - Q} = v$$

Energy of a spring:

$$E_{spring} = \frac{1}{2} C u^2$$

E_{spring} is the energy of a spring in (J)
C is spring constant (N/m) ←
u is the extention in (m)

$$F_{spring} = C \cdot u$$

Proof that the units are the same left and right of '=' sign.

$$\boxed{E_{spring} = \frac{1}{2} C u^2}$$

$$[J] = \left[\frac{N}{m}\right] \cdot [m^2]$$

$$[J] = \left[\frac{N \cdot m^2}{m}\right]$$

$$[J] = [N \cdot m]$$

$$W = F \cdot x$$

$$\boxed{E = W}$$

$$[J] = [J]$$

$$\boxed{\frac{1}{2} \cdot C \cdot u^2 = F \cdot x}$$