Task 1

Mass of the car	m	[kg]
Speed of the car	v	[m/s]
Kinetic energy of the car	E_{kin}	[J]
Potential energy of the car	E_{pot}	[J]
Height where the car should be lifted	h	[m]
Gravitational acceleration	g	[m/s^2]

Constants:

g = 9.81 m/s^2

Unit conversions:

$$1\,\frac{\mathrm{km}}{\mathrm{h}} = \frac{1000\,m}{60\cdot 60\,\mathrm{s}} = \frac{1}{3.6}\frac{\mathrm{m}}{\mathrm{s}}$$

$$1\ \mathrm{J} = 0.001\ \mathrm{kJ}$$

Formulas:

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

$$E_{\mathrm{pot}} = mgh$$

$$E_{\mathrm{kin}} = E_{\mathrm{pot}}$$

Solution:

Kinetic energy:

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

Substitute initial values

Height where the car should be lifted:

$$E_{\mathrm{kin}} = E_{\mathrm{pot}}$$

Substitute expressions

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

Solve h

$$\boldsymbol{h = \frac{v^2}{2g}}$$

Substitute initial values

Task 2

Mass of the car	m	[kg]
Width of the area of contact of one tire	w	[m]
Height of the area of contact of one tire	h	[m]
Amount of tires	N	[-]
Total area of contact	A	$[\mathrm{m}^2]$
Force exerted on the ground by the weight of the car	F_g	[N]
Pressure caused on the ground by the tires	p	[Pa]
Atmospheric pressure	p_atm	[Pa]
Gravitational acceleration	g	$[\mathrm{m/s}^2]$

Constants:

$g = 9.81\ \mathrm{m/s}^2$

$p_\mathrm{atm} = 101325\ \mathrm{Pa}$

Unit conversions:

$1\ \mathrm{cm} = 0.01\ \mathrm{m}$

1 Pa = 0.001 kPa

Formulas:

$F_\mathrm{g} = mg$

$A = Nwh$

$p = \frac{F_g}{A} + p_\mathrm{atm}$

Solution:

$p = \frac{F_g}{A} + p_\mathrm{atm}$

substitute expressions

$\boldsymbol{p = \frac{mg}{Nwh} + p_\mathrm{atm}}$

substitute initial values

Task 3

Mass of the car	m	[kg]
Speed of the car	v	[m/s]
Distance car slides against the asphalt	Δx	[m]
Distance car slides against the asphalt, winter	Δx_{win}	[m]
Force on the car generated by sliding against the asphalt	F	[N]
Force on the car generated by sliding against the asphalt, winter	F_{win}	[N]
Kinetic energy of the car	E_{kin}	[J]
Work done by braking force	W	[J]

Unit conversions:

$$1\,\frac{\mathrm{km}}{\mathrm{h}} = \frac{1000\,m}{60\cdot 60\ \mathrm{s}} = \frac{1}{3.6}\frac{\mathrm{m}}{\mathrm{s}}$$

1 N = 0.001 kN

Formulas:

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

$$W = F\Delta x$$

$$W = F_{\mathrm{win}}\Delta x_{\mathrm{win}}$$

$$E_{\mathrm{kin}} = W$$

Solution:

Force under good driving conditions

$$W = F\Delta x$$

Substitute expressions

$$E_{\mathrm{kin}} = \frac{1}{2}mv^2 = F\Delta x$$

Solve F

$$\boldsymbol{F} = \frac{\boldsymbol{mv^2}}{\boldsymbol{2\Delta x}}$$

Substitute initial values

Force during winter

$$\boldsymbol{F}_{\mathbf{win}} = \frac{\boldsymbol{mv^2}}{\boldsymbol{2\Delta x}_{\mathbf{win}}}$$

Substitute initial values

Task 4

Mass of the car	m	[kg]
Speed of the car	v	[m/s]
Heat generated during braking	Q	[J]
Efficiency of braking	η	[-]

Unit conversions:

$$1\,\frac{\mathrm{km}}{\mathrm{h}} = \frac{1000\,m}{60\cdot 60\ \mathrm{s}} = \frac{1}{3.6}\frac{\mathrm{m}}{\mathrm{s}}$$

$$1\ \mathrm{J} = 0.001\ \mathrm{kJ}$$

Formulas:

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

$$\eta = \frac{E_{\mathrm{kin}}}{Q}$$

Solution:

$$\eta = \frac{E_{\mathrm{kin}}}{Q}$$

Substitute expressions

$$\boldsymbol{\eta = \frac{mv^2}{2Q}}$$

substitute initial values

Task 5

Volume of the container	V	$[\mathrm{m}^3]$
Mass of the water	m	[kg]
Specific heat capacity of water	c	[J/(kg K)]
Density of water	ρ	$[\mathrm{kg/m}^3]$
Amount of heat supplied to the water	Q	[J]
Temperature rise that can be achieved using the heat	ΔT	[°C]

Unit conversions:

$$1\ \mathrm{l} = 1\ \mathrm{dm}^3 = 0.001\ \mathrm{m}^3$$

$$1\ \mathrm{J} = 0.001\ \mathrm{kJ}$$

Formulas:

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

$$\rho = \frac{m}{V}$$

Solution

From

$$\rho = \frac{m}{V}$$

solve *m*

$$m = \rho V$$

From

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

solve ΔT

$$\Delta T = \frac{Q}{cm}$$

Substitute expression of *m*

$$\boldsymbol{\Delta T = \frac{Q}{c\rho V}}$$

Substitute initial values