Calculation with LaTeX by means of CalcTeX – thermodynamic's exampleas

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1 Calculation with LaTeX– thermodynamics examples

This folder consider couples of examples – all files `*-calc.tex` in LaTeX input format with defined operations that are included in a single pdf document with calculated operations by means of CalcTeX package.
For received a final calculation of all `*-calc.tex` files please use a LINUX prompt command: `sh go`.
For more info please visit a web page on: http://sg.bzip.pl/CalcTeX or contact me by e-mail: CalcTeX (at) onet (dot) eu
I am open for any kind of questions or commands.
The file "`1st-example-ke-eng-calc.tex`" is the simplest and I recommend this file for study of CalcTeX used at first.
The file " http://sg.bzip.pl/CalcTeX/examples/te-en.tgz " consider all necessary files for calculation of this example if you have installed a LaTeX compiler and python language as well it's checked for LINUX system.
All files which suits to mask `*-iso-calc.tex` are autamaticlly calulated and included into single pdf format document in order to `ls *-calc.tex` comment and for calulation are included all `python` files available on `bin/py` folder.

1.1 Pressure

Determine the total pressure in a open tank containing fuel oil of density $\rho := 924 \cdot \mathrm{kg/m^3}$ at depth of $h := 2.5 \cdot \mathrm{m}$ when the atmospheric pressure is $p_{atm} := 1 \cdot \mathrm{atm}$.
Solution
Given:
$\rho \cdot (\mathrm{kg/m^3})^{-1} = 924.0$

$h \cdot \mathrm{mm}^{-1} = 2500.0$
$p_{atm} \cdot \mathrm{kPa}^{-1} = 101.325$
$g_n \cdot (\mathrm{m/s}^2)^{-1} = 9.80665$
The force due to gravity of the element is

$$F_g := m_w \cdot g_n = V_e \cdot \rho \cdot g_n = A_e \cdot h \cdot \rho \cdot g_n$$

a preassure of element due to gravity is

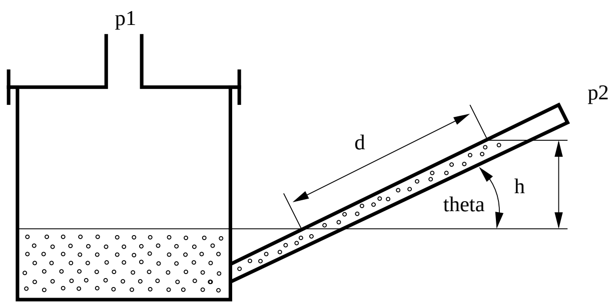
$$p_g := \frac{F_g}{A_e} = \frac{A_e \cdot h \cdot \rho \cdot g_n}{A_e}; \quad p_g := \rho \cdot g_n \cdot h; \quad p_g \cdot (\mathrm{kPa})^{-1} = 22.6533615$$

The total preassure

$$p := p_{atm} + p_g; \quad p \cdot (\mathrm{kPa})^{-1} = 123.9783615 \tag{1}$$

1.2 Oil-filled inclined leg manometer

An oil-filled inclined leg manometer is used to measure small pressure changes across an air filter in a process vent pipe. If the oil travels a distance of $d := 8.5 \cdot \mathrm{cm}$ along the leg which is inclined at an angle $\theta := 15 \cdot \mathrm{deg}$ to the horizontal, determine the gauge pressure and absolute pressure across the filter. The density of oil is $\rho := 924 \cdot \mathrm{kg/m}^3$ and the atmospheric pressure is $p_{atm} := 760 \cdot \mathrm{Tr}$.
Solution
Given:
$d \cdot \mathrm{mm}^{-1} = 85.0$
$\theta \cdot \mathrm{deg}^{-1} = 15.0$
$\rho \cdot (\mathrm{kg/m}^3)^{-1} = 924.0$
$p_{atm} \cdot \mathrm{kPa}^{-1} = 101.325$



$$\sin(\theta) = \frac{h}{d} \quad \Leftrightarrow \quad h := d \cdot \sin(\theta); \quad h \cdot \mathrm{mm}^{-1} = 22.0$$

$$\Delta p := \rho \cdot g_n \cdot (d \cdot \sin(\theta)); \quad \Delta p \cdot (\mathrm{Pa})^{-1} = 199.0$$

$p_2 := p_{atm}$

$$p_1 := \Delta p + p_2; \quad p_1 \cdot \mathrm{kPa}^{-1} = 101.524$$

1.3 Air over flat plate

Air at the preassure of $p_\infty := 0.5 \cdot \mathrm{mwc}$ (meter of water column) and temperature $T_\infty := 400 \cdot \mathrm{K}$ flows with a velocity of $u_\infty := 18 \cdot \mathrm{km/hr}$ over a flate plate $L_s := 1.32 \cdot \mathrm{m}$ long. Estimate the cooling rate per unit width of the plate needed to maitain it at a surface temperature of $T_s := 300 \cdot \mathrm{K}$.

Solution

Known:
$u_\infty \cdot (\mathrm{m/s})^{-1} = 5.0$ – velosity of air
$p_\infty \cdot \mathrm{atm}^{-1} = 0.0482952711572$, $p_\infty \cdot \mathrm{kPa}^{-1} = 4.89351835$ – preassure of air
$T_\infty \cdot \mathrm{K}^{-1} = 400.0$ – temperature of air
Air properties for $T_F := 437 \cdot \mathrm{K}$ and $p_1 := 1 \cdot \mathrm{atm}$ are:
$Pr := 0.687$
$k := 36.4 \cdot 10^{-3} \cdot \mathrm{W/(m \cdot K)}$
$\nu_1 := 30.84 \cdot 10^{-6} \cdot \mathrm{m^2/s}$ $\qquad \nu_1 \cdot (\mathrm{mm^2/s})^{-1} = 30.84$
Find:
$q \cdot (\mathrm{W/m})^{-1}$ – cooling rate per unit width of plate

The kinematic viscosity of air is possible to aproximate based on following equation at $p_2 := p_\infty$

$$\frac{\nu_1}{\nu_2} = \frac{p_2}{p_1} \quad \Leftrightarrow \quad \nu_2 := \nu_1 \cdot \frac{p_1}{p_2}; \quad \nu_2 \cdot \left(10^{-4} \cdot \frac{\mathrm{m}^2}{\mathrm{s}}\right)^{-1} = 6.3857183656 \tag{2}$$

$\nu := \nu_2$ $\qquad \nu \cdot (\mathrm{cm}^2/s)^{-1} = 6.3857183656$
The Reynolds number is

$$\mathrm{Re}_L := \frac{u_\infty \cdot L_s}{\nu}; \quad \mathrm{Re}_L = 10335.5638663 \tag{3}$$

The laminar Nuselt number aproximation for flat plate is

$$\mathrm{Nu}_L := 0.664 \cdot \mathrm{Re}_L^{1./2} \cdot \mathrm{Pr}^{1./3}; \quad Nu_L = 59.5644879273 \tag{4}$$

The average convection coefficient is then

$$h := \frac{\mathrm{Nu}_L \cdot k}{L_s}; \quad h \cdot \left(\frac{\mathrm{W}}{\mathrm{m}^2 \cdot \mathrm{K}}\right)^{-1} = 1.64253587921 \tag{5}$$

For plate and of unit width, it follows from Newton's law of cooling that the rate of convection heat transfer to plate is

$$q := h \cdot L_s \cdot (T_\infty - T_s); \quad q \cdot \left(\frac{\mathrm{W}}{\mathrm{m}}\right)^{-1} = 216.8 \tag{6}$$