Bernoulli's (Energy) Equation Application

This application will solve the Bernoulli's Equation for unknown variables and includes programs that solve for head losses required in the Energy Equation. READ this in its entirety before use as there are assumptions and limitations on its use. This program was designed for the TI Nspire CAS and I am unsure of its functionality on a non-CAS TI Nspire. Here are the primary assumptions when using this program:

1. Units must be converted and equivalent before use in this program. This program will not convert units and the result is only as good as the input. In other words, if the units are incorrectly converted before input the result will obviously be incorrect.
2. There are assumptions and limitations to the Bernoulli, Darcy-Weisbach, and Hazen-Williams equation and it is assumed you are aware of these prior to use. For example, if a pipe is open to the atmosphere the pressure is 0. If you are doing an example problem and aren't given elevation values that typically means there isn't a large enough difference for elevation head to be relevant. Therefore when using this program you would input 0 as the pressure value etc.
3. There are two forms of the Bernoulli Energy Equations included, one for incompressible fluids and the other for compressible. Water is considered incompressible in nearly all applications, so the "energy()" function should be used if that is the fluid considered.

This is not a complete list of assumptions as indicated above; however, they should be sufficient.

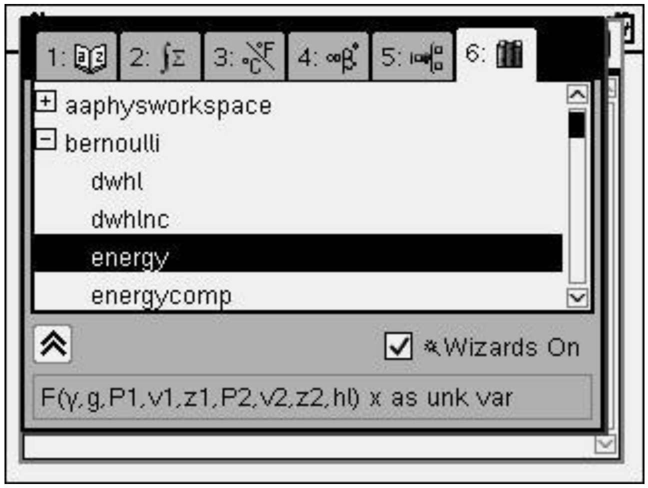
Energy() is a program that solves the Energy Equation assuming incompressible flow as seen below:

$$\frac{p_1}{\gamma} + \frac{v_1^2}{2g} + z_1 + \cancel{h_A} = \frac{p_2}{\gamma} + \frac{v_2^2}{2g} + z_2 + \cancel{h_R} + h_L$$

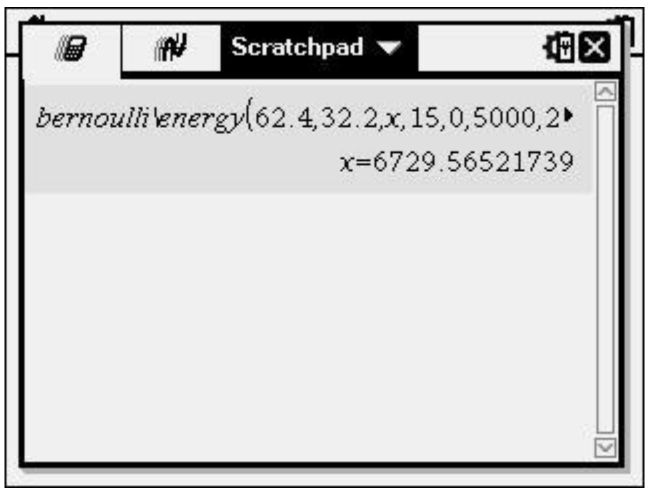
*Note – ha and hr are net head values that are either added to the system or removed by mechanical devices. I have not included them in this program as default variables. Therefore if additional head is removed (hr) add it to your hl value. Accordingly, minor losses should be added to the hl value. If head is added (ha) to the system, it should be subtracted from the total headloss (hl) due to manipulation of the equation.

"x" should be input into function indicating the requested value needed. *Note it will not solve more variables than equations provided (i.e. if velocity is constant "x" should be placed in v1 & v2 inputs.) Here is an example of how to input into this function:

The wizard will display how the variables are input when pulled up in the library:



Given the values of z_1 = 0 ft, z_2 = 20 ft, p_2 = 500 lb/ft^2, v_1 = 50 ft/s, v_2 = 20 and h_l = 5 ft and solving for p_1 assuming the fluid is water and that would mean the specific weight of 62.4 lb/ft^3 and gravity constant of 32.2 ft/s^2 the input would be such:



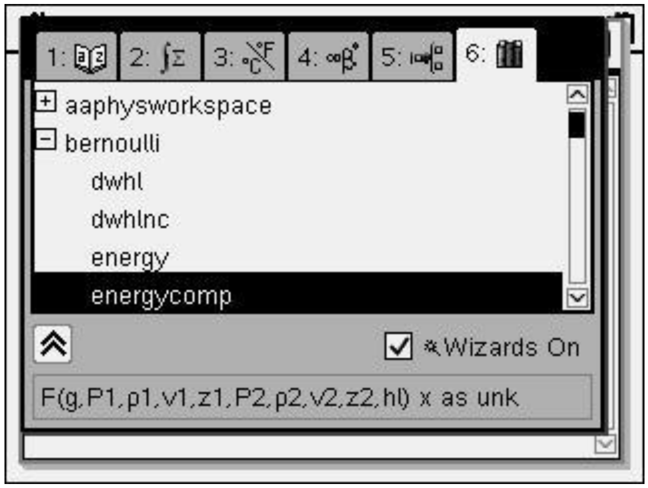
This gives the p_1 value of 6729.56 lb/ft^2. It's important to note that in all calculations you need as many equations as unknown variables. You can also input symbolic variables if you have multiple unknowns if you use this in conjunction with the other known equation. And as a last reminder these units were already converted and equivalent, the answer will not be right if you do not account for this.

Energycomp() is also included and is the compressible fluids form of the Energy Equation if needed. This expanded equation is shown below:

$$\frac{P_1}{\rho_1 g} + \frac{v_1^2}{2g} + z_1 + \cancel{h_A} = \frac{P_2}{\rho_2 g} + \frac{v_2^2}{2g} + z_2 + \cancel{h_R} + h_L$$

*See Note above under the incompressible fluid equation for explanation of removal of ha and hr variables.

An example of use of this equation is not given as it is the same as above except instead of specific weight for the fluid you will give the densities at point 1 and point 2 as the equation requires. Refer to the wizard for the required input variables (see below):

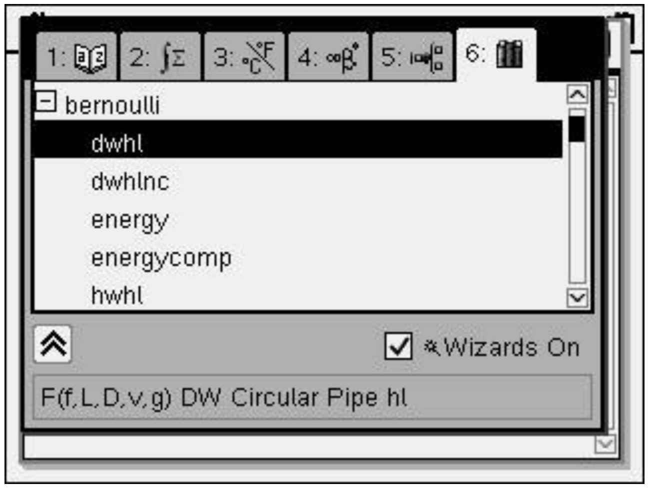


Dwhl() is the Darcy-Weisbach Equation for headloss within a circular pipe and will stored the headloss as the variable “hl” in the calculator. Make note of the value if you are calculating additional losses as you will need to sum all losses for use in the equation. The equation can be seen below and the required variables. This shows the US units but the equivalent SI units can be found online and be used instead:

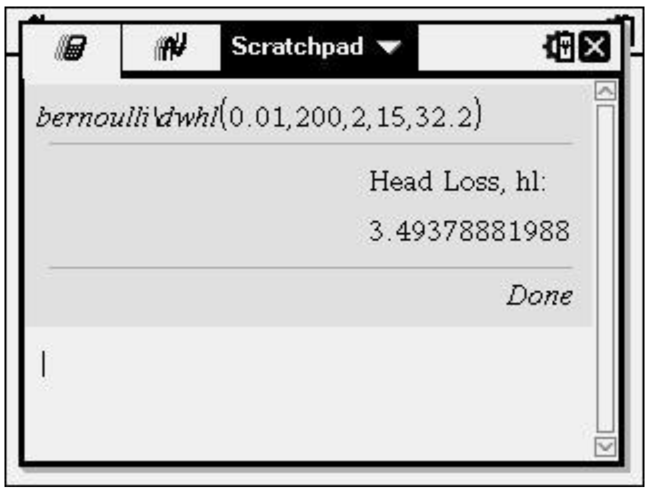
$$h_f = f\,(L/D) \times (v^2/2g)$$

h_f = head loss (ft)
f = friction factor
L = length of pipe work (ft)
d = inner diameter of pipe work (ft)
v = velocity of fluid (ft/s)
g = acceleration due to gravity (ft/s²)

This program can be used as follows:



Using a friction factor of 0.01, L = 200 ft, D = 2 ft, v = 15 ft/s and g = 32.2 ft/s^2



This gives a head loss of 3.49 ft which can in turn be used in the Bernoulli energy equation solver (1st program, see above.)

Dwhlnc() is the Darcy-Weisbach Equation for headloss within a non-circular conduit/pipe and will be stored as variable “hl” within the calculator. See above regarding summation of headloss values. The units or equivalents are the same as above. “R” is simply the hydraulic radius of the conduit in appropriate units.

$$h_L = f \times \frac{L}{4R} \times \frac{v^2}{2g}$$

This program can be used just as the above program dwhl by using the prompt in the wizard as a guide for input. Remember to use equivalent terms as always. This can also be used in the Bernoulli energy equation solver.

Hwhl() is the Hazen-Williams Equation for headloss with a conduit and can only be used with water as the fluid. The calculated value is stored as the variable “hl” within the calculator after execution. (*There are additional limitations/assumptions with this equation and should be known prior to use.)

The equation is shown below:

$$h_L = L\left[\frac{Q}{1.32AC_hR^{0.63}}\right]^{1.852}$$

Q in ft^3/s
A in ft^2
h_L, L, and R in ft

This program can be used just as the other head loss programs above.

Mhl() is the minor loss equation. It will require an additional reference to determine the need K coefficient. This is provided as a convenience and as above is stored as the variable “hl” in the calculator after executed. The equation is provided below:

$$h_L = K\left(\frac{v^2}{2g}\right)$$

h_L = minor head loss
K = loss coefficient
v = average velocity of flow near minor loss

This program can be used as the other head loss programs above.

As a final note, sum all relevant head losses and minor losses as applicable before using the Bernoulli solver and minus any additions of head from pumps etc as applicable.

It is recommended that the user also downloads my Darcy-Weisbach Application as there are additional tools that can be used in conjunction with this application. That application can calculate the friction factor “f” used above as well as the Reynolds number and viscosity of water.

For use on your calculator: Copy “DarcyWeisbach.tns” to the “MyLib” folder in your TI Nspire (Create the folder in the root if it does not exist already.) After transferring to the calculator be sure to refresh libraries. (In calculator mode, click Doc-> 6:Refresh Libraries.) Let it update and then you should be able to access it in the library under the 6: tab.

Let me know if you notice any mistakes or issues.

Thank you,

Brian