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RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree in Applied Sciences
Third Year Semester I Examination – September/October 2019

PHY 3214 – GRAPHICAL PROGRAMMING FOR PHYSICS

Time: Two (02) hours

- **Answer All Questions**
- **Help (available on the software) is permitted to be used.**
- **This examination requires you to prepare the answer script on a MS word document and save it with your name and index number.**
- **Note: Do not forget to save your work (in the word document) regularly.**
- **At the end of the exam save your answers and move them into the drive provided to you by the technical staff.**

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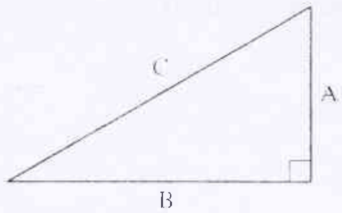
1. a) According to Pythagorean Theorem, the length of the hypotenuse (C) of a right triangle is related to the lengths of the other two sides by

$$C^2 = A^2 + B^2$$



Create a VI that will accept values for A and to calculate and display the C value.

(10 marks)

Test your VI with $A = 3, B = 4, C = 5$.
Then, solve for C using the following values:

(i) $A = 3.3, B = 4.1$
(ii) $A = 7, B = 2$

(05 marks)

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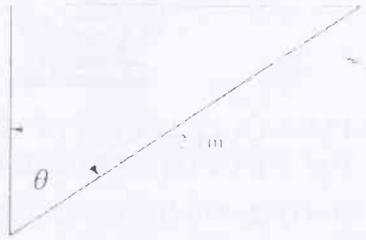
b) Given the lengths of each of the sides of the right triangle shown in the figure below, create a VI to evaluate the sine, cosine, and tangent of angle θ.



(10 marks)

2. When fluids have to be transported long distances, pipelines can be an efficient, safe and economical alternative to trucking. However, due to fluid friction fluid pressure falls over distances. Therefore, pumping stations are required at intervals to re-pressurize the fluid.

   The pressure drop between pumping stations due to fluid friction is modelled by,

$$\Delta P = \frac{1}{2} f \rho \frac{L}{D} V_{\text{avg}}^2$$

   where f is the Moody (or Darcy) friction factor (no units); ρ is the fluid density (kg/m^3); L is the distance between pumping stations (m); D is the pipe diameter (m) and V_{avg} is the average fluid velocity (m/s)

   Create a VI that allows you to enter the required values, and then calculate and display the pressure drop in Pa (Pa $= 1\ \text{N/m}^2$) and bars (1 bar $= 10^5$ Pa).

(10 marks)

   Use the following values to test your VI.

   $f = 0.008$
   $\rho = 800\ \text{kg/m}^3$
   $L = 15000\ \text{m}$
   $D = 0.2\ \text{m}$
   $V_{\text{avg}} = 1.5\ \text{m/s}$
   $\Delta P = 5.4\ \text{bar}$

(01 mark)

   Using your tested VI, answer the following questions:

   a) What is the pressure drop increase if the distance between piping stations is 20000 m? **(02 mark)**

   b) What is the maximum distance between pumping stations to keep the pressure drop below 5 bars? **(02 mark)**

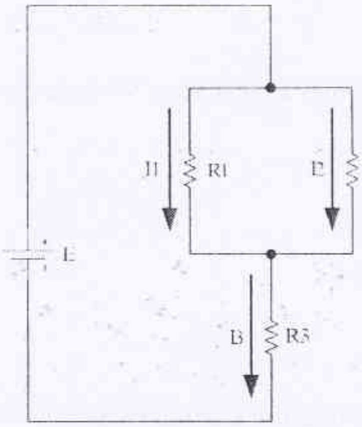
Continued...

c) To increase throughput, it has been proposed to increase the average fluid velocity to 2.2 m/s. What is the expected pressure drop at the higher flow rate over a distance of 15 km? **(03 marks)**

d) What will be the pressure drop if a different fluid of density 1100 kg/m^3 is transported in the pipeline? Assume V_{avg} = 1.5 m/s over the same distance **(02 marks)**

3. Use Kirchhoff's Laws to develop three equations to solve for the three currents ((I1, I2, I3) indicated in the following figure. The known quantities are as follows:

E = 20 V
R1 = 120 Ω
R2 = 150 Ω
R3 = 30 Ω



(Hint: Kirchhoff's Laws: $\sum_{k=1}^{n} I_k = 0$, $\sum_{k=1}^{n} V_k = 0$ and $\varepsilon - IR_{eq} = 0$)

(25 marks)

4. In fluid mechanics, friction factor plays an essential role in determining pressure drop, due to fluid friction, in pipeline systems. The equation used to calculate friction factor depends on the type of fluid flow. (The two types of flow are called 'laminar' and 'turbulent' flow. However, you don't need to know that to solve this problem). Consider that if the Reynolds number is less than 2100, the flow is laminar, and otherwise the flow is turbulent. The Reynolds number for a pipe flow is given by,

$$Re = \frac{D\,V_{avg}\,\rho}{\mu}$$

where,
D is the pipe diameter (m)
V_{avg} is the flow velocity (m/s)
ρ is the fluid density (kg/m^3)
μ is the fluid viscosity (kg/ms)

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If the flow is laminar ($Re < 2100$), the friction factor is calculated as

$$f = \frac{64}{Re}$$

However, if the flow is turbulent, the friction factor is calculated in a variety of ways depending on the Reynolds number and the type of pipe. One way to calculate friction factor for low-Re turbulent flow in smooth pipes is

$$f = 0.184\, Re^{-0.2}$$

Create a VI that accepts D, V_{avg}, ρ and μ as inputs, calculate Reynolds number, and then uses a Case Structure to solve for friction factor using the appropriate equation.

(10 marks)

Use the following values to test your VI for a slow, room temperature water flow:

$D = 0.02$ m
$V_{\text{avg}} = 0.1$ m/s
$\rho = 1000$ kg/m^3
$\mu = 0.001$ kg/m s
$Re = 2000$
$f = 0.032$

Then use your VI to find the friction factor for the following flows:

a) Fast room temperature water flow

$D = 0.02$ m
$V_{\text{avg}} = 0.1$ m/s
$\rho = 1000$ kg/m^3
$\mu = 0.001$ kg/m s

(05 marks)

b) Flowing honey

$D = 0.02$ m
$V_{avg} = -0.01$ m/s
$\rho = 1400$ kg/m^3
$\mu = 7$ kg/m s

(05 marks)

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