

Question1.

Answer 1.

Given:

A. Radiant heat transfer equation:

$$q = \sigma FEA(T_h^4 - T_c^4)$$

$$q = (T_h^4 - T_c^4) / (1/\sigma FEA)$$

In case of heat flow system, the temperature is the potential difference.

Therefore, the Universal flow principle is stated by the equation:

$$q = \Delta F / R$$

Where, q = instantaneous flow rate (energy or mass) through CV

ΔF = Driving force difference causing the flow

R = Resistance to the flow

After comprising both the equations we get:

Driving force $\Delta F = (T_h^4 - T_c^4)$

Resistance $R = 1 / \sigma FEA$

B. Pressure loss in a pipeline:

$$\Delta P = K v^2 Y / 2g$$

In the fluid flow system because of the potential caused due to pressure difference, fluid flow occurs.

$$v = (2g \Delta P) / (KY)^2$$

$$\text{Driving force } \Delta F = (\Delta P)^2$$

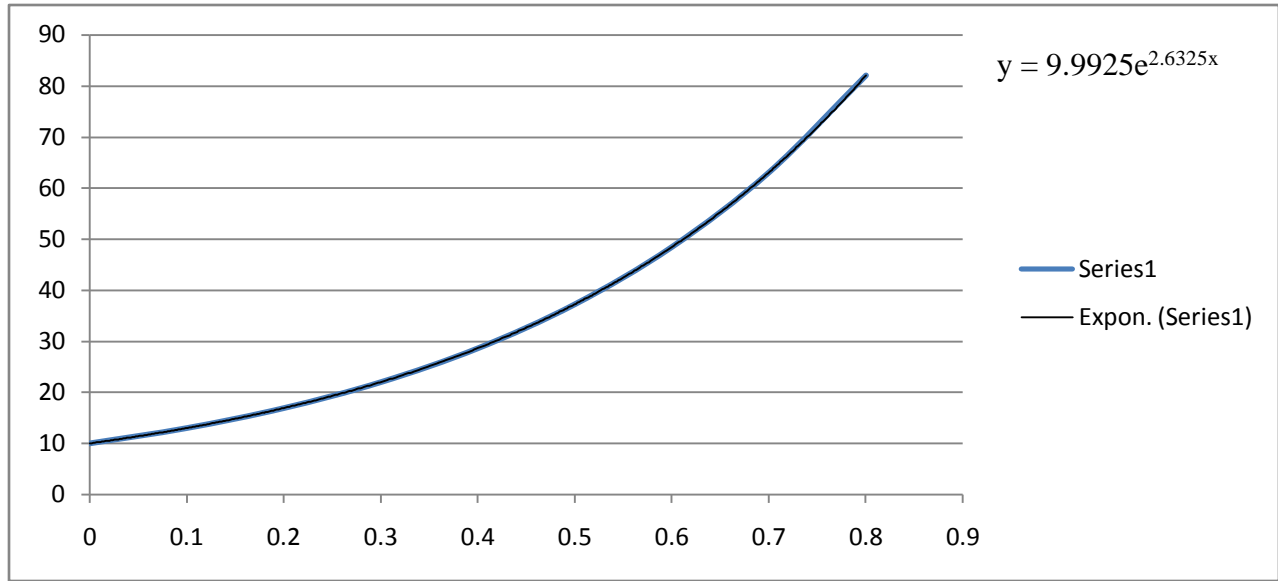
$$\text{Resistance } R = (KY/2g)^2$$

Question 4. $\frac{dx}{dt} = 3x + t$

Answer 4.

a. $\frac{dx}{dt} = 3x + t ; X_1 = X_0 + h(X'_0)$

t0	x0	x'0	x1
0	10	30	13
0.1	13	39.1	16.91
0.2	16.91	50.93	22.003
0.3	22.003	66.309	28.6339
0.4	28.6339	86.3017	37.2641
0.5	37.2641	112.292	48.4933
0.6	48.4933	146.08	63.1013
0.7	63.1013	190.004	82.1017
0.8	82.1017	247.105	106.812



b.

The Runge-Kutta 4th order method is based on the following

$$x_{i+1} = x_i + \frac{1}{6}(k_1 + 2k_2 + 2k_3 + k_4)h$$

$$k_1 = f(t_i, x_i)$$

$$k_2 = f\left(x_i + \frac{1}{2}h, y_i + \frac{1}{2}k_1h\right)$$

$$k_3 = f\left(x_i + \frac{1}{2}h, y_i + \frac{1}{2}k_2h\right)$$

$$k_4 = f(x_i + h, y_i + k_3h)$$

$$\frac{dx}{dt} = 3x + t; x(0) = 10$$

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$$\frac{dx}{dt} = 3x + t$$

$$x_{i+1} = x_i + \frac{1}{6}(k_1 + 2k_2 + 2k_3 + k_4)h$$

For $i = 0, t_0 = 0, x_0 = 10$

$$k_1 = f(t_0, x_0)$$

$$= f(0, 10)$$

$$= 3(10) + 0$$

$$= 30$$

$$k_2 = f\left(t_0 + \frac{1}{2}h, x_0 + \frac{1}{2}k_1h\right)$$

$$= f\left(0 + \frac{1}{2}(0.1), 10 + \frac{1}{2}(30) \times 0.1\right)$$

$$= f(0.05, 11.5)$$

$$= 30.2$$

$$k_3 = f\left(t_0 + \frac{1}{2}h, x_0 + \frac{1}{2}k_2h\right)$$

$$= 34.58$$

$$k_4 = f(t_0 + h, x_0 + k_3h)$$

$$= 40.474$$

x_1 is the approximate temperature at

$$t = t_1$$

$$= t_0 + h$$

$$= 0 + 0.1$$

$$= 0.1$$

$$x_1 = x(0.1)$$

$$= 13.3339$$

For $i = 1, t_1 = 0.1, x_1 = 13.3339$

$$k_1 = f(t_1, x_1)$$

$$= 40.1017$$

$$k_2 = f\left(t_1 + \frac{1}{2}h, x_1 + \frac{1}{2}k_1h\right)$$

$$= 40.3017$$

$$k_3 = f\left(t_1 + \frac{1}{2}h, x_1 + \frac{1}{2}k_2h\right)$$

$$= 46.197$$

$$k_4 = f(t_1 + h, x_1 + k_3h)$$

$$= f(240 + 240, 675.65 + (-0.34775) \times 240)$$

$$= 54.0608$$

$$x_2 = x_1 + \frac{1}{6}(k_1 + 2k_2 + 2k_3 + k_4)h$$

$$= 17.7866$$

x_2 is the approximate temperature at

$$t = t_2$$

$$= t_1 + h$$

$$= 0.1 + 0.1$$

$$= 0.2$$

$$x_2 = x(0.2)$$

$$= 17.7866$$

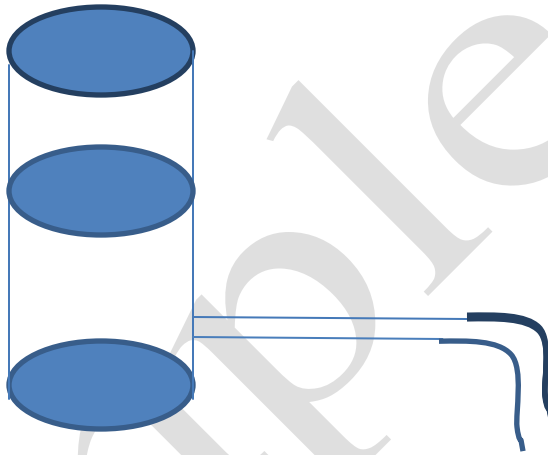
The below mentioned table prepared in the Excel shows the details about the solution:

h	0.1					
t0	0					
x0	10		3x+t			
i	T	x	k1	k2	k3	k4
0	0	10	30	30.2	34.58	40.474
1	0.1	13.3339	40.1017	40.3017	46.197	54.0608
2	0.2	17.7866	53.5597	53.7597	61.6736	72.1618
3	0.3	23.7297	71.4891	71.6891	82.2925	96.2768
4	0.4	31.6585	95.3755	95.5755	109.762	128.404
5	0.5	42.2328	127.198	127.398	146.358	171.206

6	0.6	56.3314	169.594	169.794	195.113	228.228
7	0.7	75.1253	226.076	226.276	260.067	304.196
8	0.8	100.175	301.324	301.524	346.602	405.405
9	0.9	133.558	401.573	401.773	461.889	540.24
10	1	178.043	535.13	535.33	615.479	719.873

Question 3.

Solution 3.

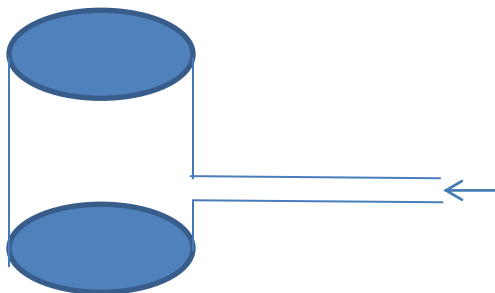


Question 4.

Solution

As we know from

a.



b. ;

c. As per the Hydraulic loop law: $\sum_i \Delta P_i = 0$... (1)

Using the Darcy-Weisbach equation, the pressure drop in a pipe due to friction is given by:

$$\Delta P = (f_D L \rho v^2) / 2D \quad \dots (2)$$

Where

f_D = Darcy friction factor

L = length of pipe (in m)

D = is the hydraulic diameter of the pipe (in m)

v = average flow velocity of fluid (in ms⁻¹)

ρ = density of fluid (in kgm⁻³)

ΔP = pressure drop due to friction (in Nm⁻²)

We know that pipes are full of water which are incompressible, therefore

$$m = \rho v A \quad \dots (3)$$

Where,

m = mass flow rate (in kgs⁻¹)

ρ = fluid density (in kgm⁻³)

v = average flow velocity (in ms^{-1})

A = cross sectional area of fluid, in our case inside pipe area (in m^2)

Pressure change due to elevation difference is given by

$$\Delta PE = (E_0 - E_T)\rho g \quad (3) \quad \dots(4)$$

where

E_0 = elevation at origin of pipe (in m)

E_T = elevation of termination of pipe (in m)

ρ = fluid density (in kgm^{-3})

g = gravitational acceleration (in ms^{-2})

ΔPE = pressure drop due to elevation (in Nm^{-2})

Rearranging equation 3 we get: $v = m/\rho A \quad \dots(5)$