Question1.

Answer 1.

Given:

A. Radiant heat transfer equation:

q= σFEA(Th^4-Tc^4)

q=(T_h4−Tc_4) / (1/σ FEA)

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

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

q =Δ F / R

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

Δ F =Driving force difference causing the flow

R=Resistance to the flow

After comprising both the equations we get:

Driving forceΔ F = (Th4-Tc4)

ResistanceR=1 / σFEA

B. Pressure loss in a pipeline:

ΔP =Kv2Y/2g

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

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

Driving force $\triangle F = (\triangle P)^2$

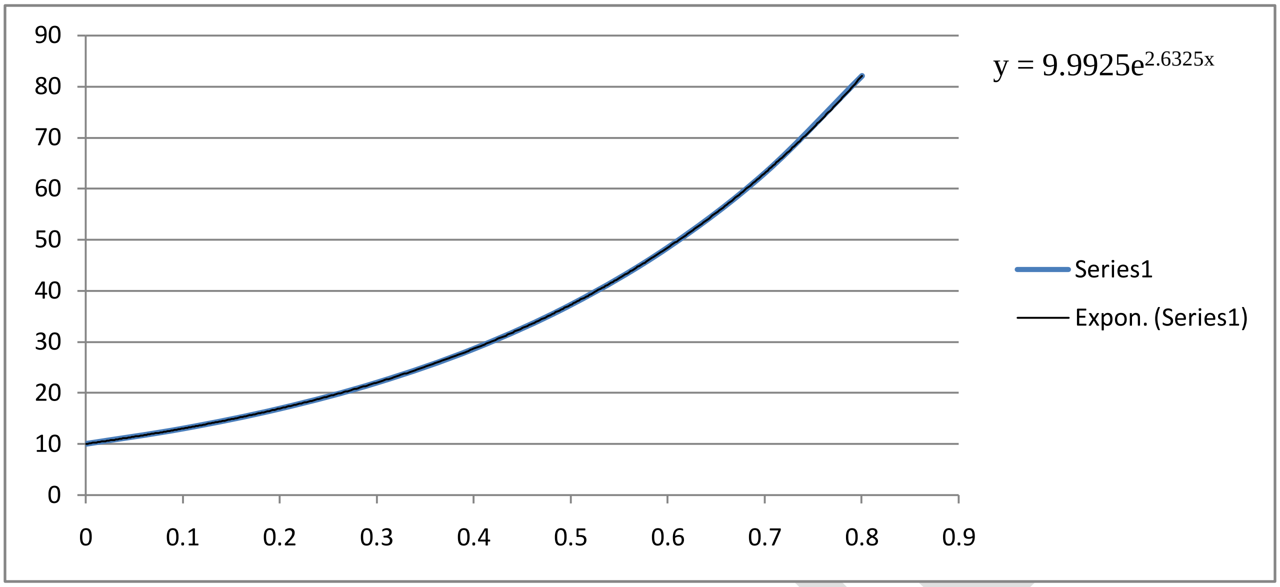
Resistance $R = (KY/2g)^2$

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

$$
\begin{aligned}
x_{i+1} &= x_i + \frac{1}{6}(k_1 + 2k_2 + 2k_3 + k_4)h \\
k_1 &= f(t_i, x_i) \\
k_2 &= f\left(x_i + \frac{1}{2}h, y_i + \frac{1}{2}k_1 h\right) \\
k_3 &= f\left(x_i + \frac{1}{2}h, y_i + \frac{1}{2}k_2 h\right) \\
k_4 &= f(x_i + h, y_i + k_3 h)
\end{aligned}
$$

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

233

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

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

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

$$k_1 = f(t_0, x_0)$$
$$= f(0,10)$$
$$= 3(10) + 0$$
$$= 30$$

$$k_2 = f\left(t_0 + \frac{1}{2}h, x_0 + \frac{1}{2}k_1 h\right)$$
$$= f\left(0 + \frac{1}{2}(0.1), 10 + \frac{1}{2}(30) \times 0.1\right)$$
$$= f(.05, 11.5)$$
$$= 30.2$$

$$k_3 = f\left(t_0 + \frac{1}{2}h, x_0 + \frac{1}{2}k_2 h\right)$$

= 34.58

$$k_4 = f(t_0 + h, \theta_0 + k_3 h)$$

= 40.474

x_1 is the approximate temperature at

$$t = t_1$$
$$= t_0 + h$$

= 0+.1

= .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

$$k_2 = f\left(t_1 + \frac{1}{2}h, x_1 + \frac{1}{2}k_1 h\right)$$

$= 40.3017$

$$k_3 = f\left(t_1 + \frac{1}{2}h, x_1 + \frac{1}{2}k_2 h\right)$$
$= 46.197$

$$k_4 = f\left(t_1 + h, x_1 + k_3 h\right)$$
$= f\left(240 + 240, 675.65 + (-0.34775) \times 240\right)$
$= 54.0608$

$$x_2 = x_1 + \frac{1}{6}(k_1 + 2k_2 + 2k_3 + k_4)h$$
$= 17.7866$

x_2 is the approximate temperature at

$t = t_2$
$= t_1 + h$
$= 0.1 + 0.1$
$= 0.2$

$$x_2 = x(0.2)$$
$= 17.7866$

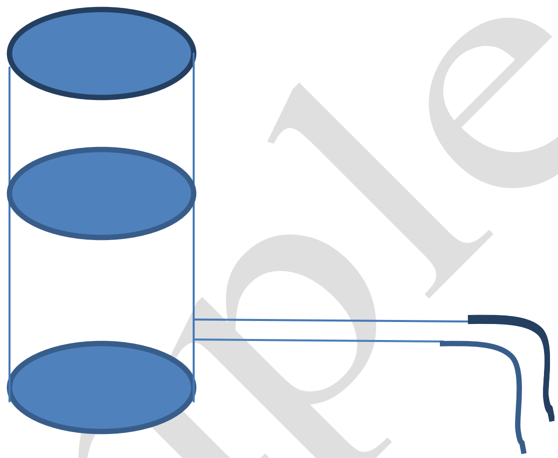
The below mentioned table prepared in the Excel shows the details about the solution:

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.

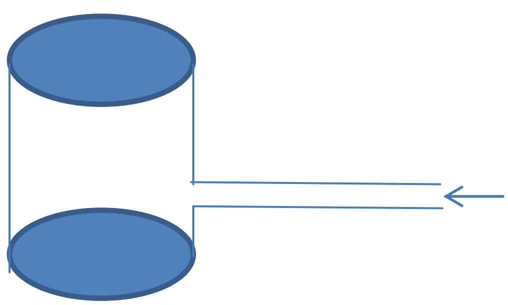


Question 4.

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:

$\Delta P = (f_D \, L \, \rho v^2)/2D$ ...(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

$m = \rho v A$ ...(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 m2)

Pressure change due to elevation difference is given by

$\Delta PE=(E0-ET)\rho g(3)$ …(4)

where

E0= elevation at origin of pipe (in m)

ET= 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: $v=m/\rho A$ ...(5)