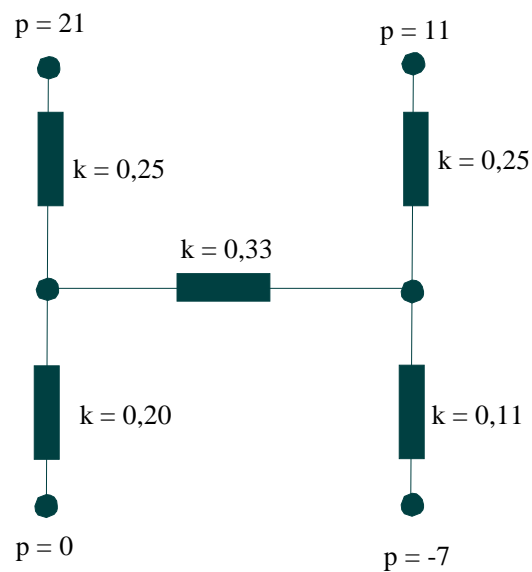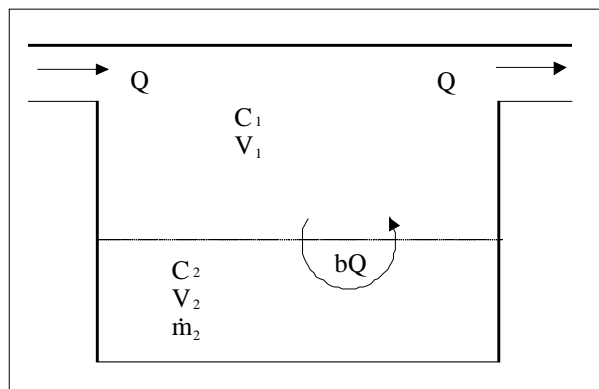1   Air is flowing in a duct, mass flow rate 0.5 kg/s and specific heat capacity 1.00 kJ/kgK. The length of the duct is 20 m and the conductance to the environment 12 W/Km. Temperature of the arriving air is 5 °C and the temperature of the duct environment is 22 °C. Make a three-node difference model of the duct and compute the temperature of the leaving air. Compare the result with the analytical solution.

2   Attached figure shows an open network. Compute the mass flow rates in the network using Hardy-Cross method. The dimension of the pressures p is Pa and the dimension of the flow resistances k is $Pa/(kg/s)^2$. The flow is assumed turbulent.

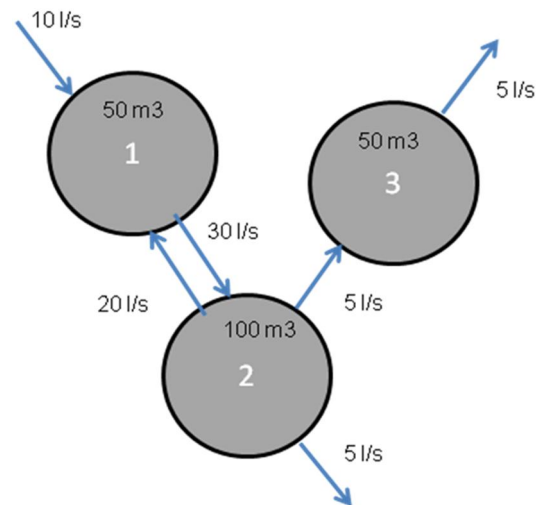p = 21
p = 11
k = 0,25
k = 0,25
k = 0,33
k = 0,20
k = 0,11
p = 0
p = -7

3   Estimate the contaminant removal efficiency of an industrial hall using a 2-zone model.
The supply air flow Q=2.5 kg/s is equal to the exhaust air flow. The only contaminants source m=5.0 mg/s is located in the lower zone 2. The contaminants are assumed to be fully mixed inside each zone. The volumes of the zones are V_1=8000 m³ ja V_2=2000 m³. The mixing air flow between the zones is bQ, where b gets three different values 0.05, 0.1 and 0.2.

Q
Q
C_1
V_1
C_2
V_2
$\dot{m}_2$
bQ

4   In a system (building) made up of three zones (spaces) the air flows and zone volumes are according to the adjacent figure. Calculate the contaminant concentrations in the zones during 6 hours when a contaminant source Q_c = 5 ml/s is activated in the zone 1 at the time t=0.

5   Make a dynamic thermal model for a Purmo Hygiene radiator, height 500 mm and length 1200 mm. Using the model, calculate the return water temperature as a function of time when the radiator valve is opened at t=0 and the water mass flow rate has a step change from 0.0 to 0.004 kg/s. The supply water temperature is 45 $^{\circ}$C and the initial temperature of the radiator ant its environment is 21 $^{\circ}$C.

Purmo Hygiene Heat output

Type	10	20	30	10	20	30	10	20	30
Height, mm	450	450	450	500	500	500	600	600	600
Norm output, W/m	498	863	1205	546	938	1309	639	1085	1510
Exponent, n	1,317	1,305	1,301	1,309	1,286	1,305	1,292	1,288	1,310
Length, mm									
400	199	345	482	218	375	524	256	434	604
500	249	431	602	273	469	654	319	542	755
600	299	518	723	328	563	785	383	651	906
700	349	604	843	382	657	916	447	759	1057
800	398	690	964	437	750	1047	511	868	1208
900	448	777	1084	491	844	1178	575	976	1359
1000	498	863	1205	546	938	1309	639	1085	1510
1100	548	949	1325	601	1032	1440	703	1193	1661
1200	598	1036	1446	655	1126	1571	767	1302	1812
1400	697	1208	1687	764	1313	1833	895	1519	2114
1600	797	1381	1928	874	1501	2094	1022	1736	2416
1800	896	1553	2169	983	1688	2356	1150	1953	2718
2000	996	1726	2410	1092	1876	2618	1278	2170	3020
2200	1096	1899	2651	1201	2064	2880	1406	2387	3322
2300	1145	1985	2771	1256	2157	3011	1470	2495	3473
2600	1295	2244	3133	1420	2439	3403	1661	2821	3926
3000	1494	2589	3615	1638	2814	3927	1917	3255	4530