Name:

Enrolment No:

UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2018

Program/Course: M.Tech (CE + PD) **Semester: I**
Subject- Fluid Flow and Heat Transfer Equipment Design **Time: 03hrs**
Code: CHPD 7005 **Max. Marks: 100**

Instructions: *The question paper consists of two sections. Answer the questions section wise in the answer booklet.

Note: Assume suitable data wherever necessary

SECTION A

Attempt all the questions. All questions carry equal marks

Total Marks=60

<table>
<tr><th>S. No.</th><th></th><th>Marks</th><th>CO</th></tr>
<tr><td>Q 1</td><td>A horizontal venturimeter with inlet diameter 20 cm and throat diameter 10 cm used to measure the flow of oil of specific gravity 0.8. The discharge of oil through venturimeter is 60 litres/s. Find the reading of the oil-mercury differential manometer. Take C_d=0.98 and specific gravity of mercury 13.6.</td><td>10</td><td>CO1</td></tr>
<tr><td>Q2</td><td>Derive general unsteady state heat conduction equation in Cartesian Co-ordinates.</td><td>10</td><td>CO2</td></tr>
<tr><td>Q3</td><td>Explain Grand Composite Curve.</td><td>10</td><td>CO4</td></tr>
<tr><td>Q4</td><td>A heat exchanger network will involve the four process streams shown below:
<table>
<tr><th>Stream</th><th>Supply temperature, TS (°C)</th><th>Target temperature, TT (°C)</th><th>Heat capacity flow rate, CP (kW/°C)</th></tr>
<tr><td>1</td><td>220</td><td>150</td><td>2.0</td></tr>
<tr><td>2</td><td>240</td><td>60</td><td>3.0</td></tr>
<tr><td>3</td><td>50</td><td>190</td><td>2.5</td></tr>
<tr><td>4</td><td>100</td><td>210</td><td>4.0</td></tr>
</table>
A minimum temperature difference of 10°C will be used for design purposes. Set up the problem table for the network and use it to determine:
(a) The minimum hot and cold utility requirements
(b) The hot and cold stream temperatures at the pinch</td><td>10</td><td>CO4</td></tr>
<tr><td>Q5</td><td>Explain basic construction of furnace and its applications.</td><td>10</td><td>CO5</td></tr>
</table>

Q6

A chemical is heated by water in heat exchanger. 2 kg/s of water flow through heat exchanger with an inlet temperature of 110ºC. Mass flow rate and inlet temperature of chemical is 3 kg/s and 20 ºC. The specific heats of the water and chemical are given to be 4.18 and 1.8 kJ/kg.°C, respectively. The overall heat transfer coefficient 1.2 kW/m^2 ºC. Heat transfer area 7 m^2. Determine the outlet temperatures of both the fluids. Assume it's a parallel flow heat exchanger.

10

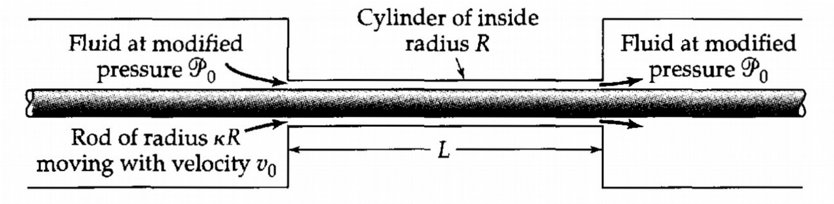
CO3

SECTION-B (Total Marks-40)

Answer all questions.

Q7

A cylindrical rod of radius kR moves axially with velocity $v_z = v_o$ along the axis of a cylindrical cavity of radius R as seen in the figure. The pressure at both ends of the cavity is the same, so that the fluid moves through the annular region solely because of the rod motion.



(a) Find the velocity distribution in the narrow annular region.

(b) Find the mass rate of flow through the annular region.

20

CO1

Q8

In a 1-6 shell and tube heat exchanger, 17 kg/sec of kerosene will be heated from 75 to 120ºF by cooling a gasoline stream from 160 to 120ºF. Fouling factor of hot fluid of 352.13 m^2 K/W, and for cold fluid of 176.06 m^2 K/W. Find individual heat transfer coefficient and heat load. Tube inner diameter of 0.212 m, tube outer diameter of 0.254 m and tube length of 7.315 m. Thermal Conductivity of tube is 121 W/(m K).

Fluid properties	***Gasoline***	***Kerosine***
Viscosity	0.0002 kg/(m s)	0.0016 kg/(m s)
Density	685 kg/m^3	800 kg/m^3
Thermal Conductivity	0.129 W/(m K)	0.144 W/(m K)
Specific heat capacity	2.39 kJ/(kg K)	2.01 kJ/(kg K)

Tube pitch is 1.25 inch, baffle spacing 15.5 inch and shell inside diameter is 31 inch.

20

CO3

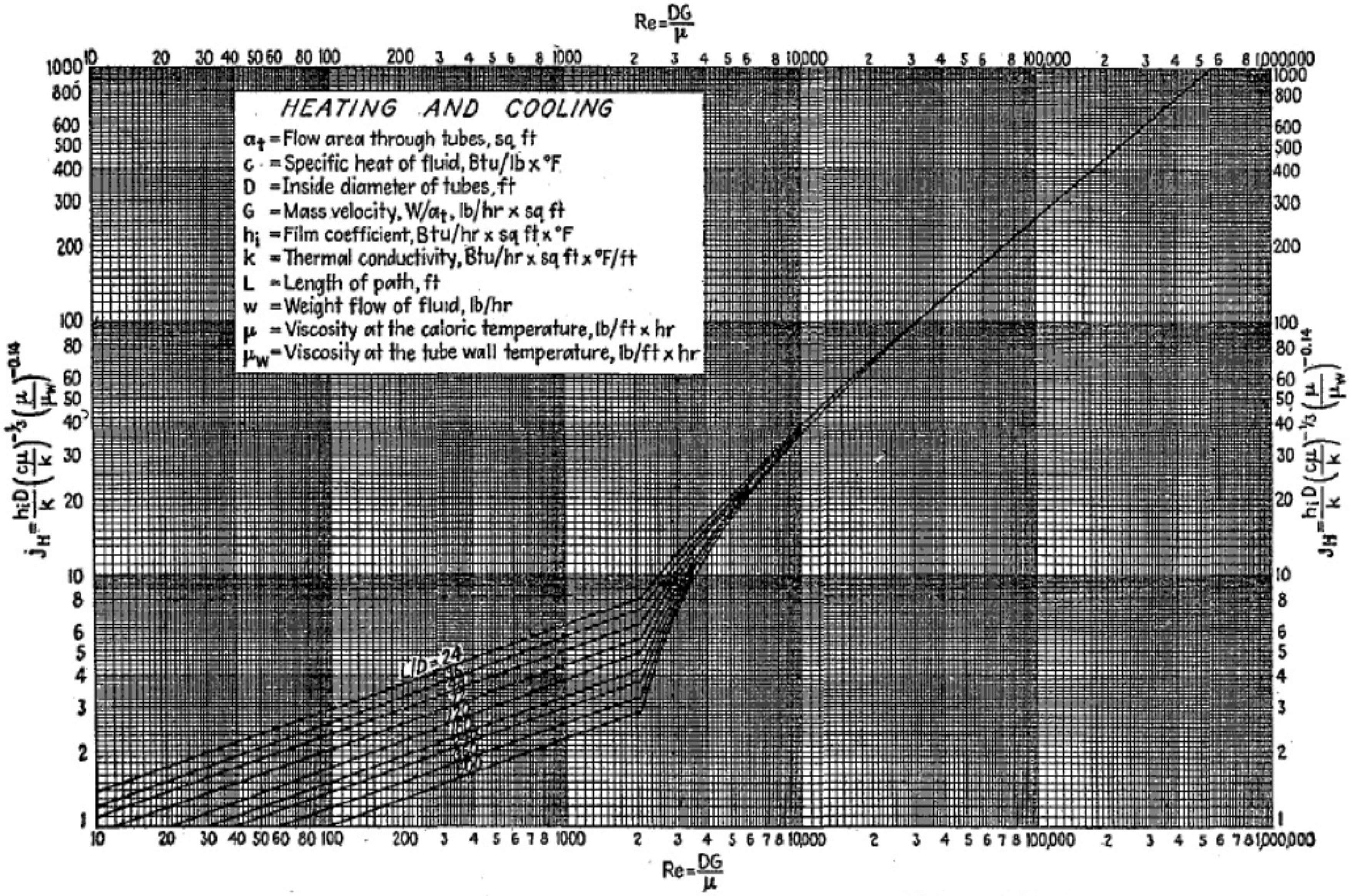
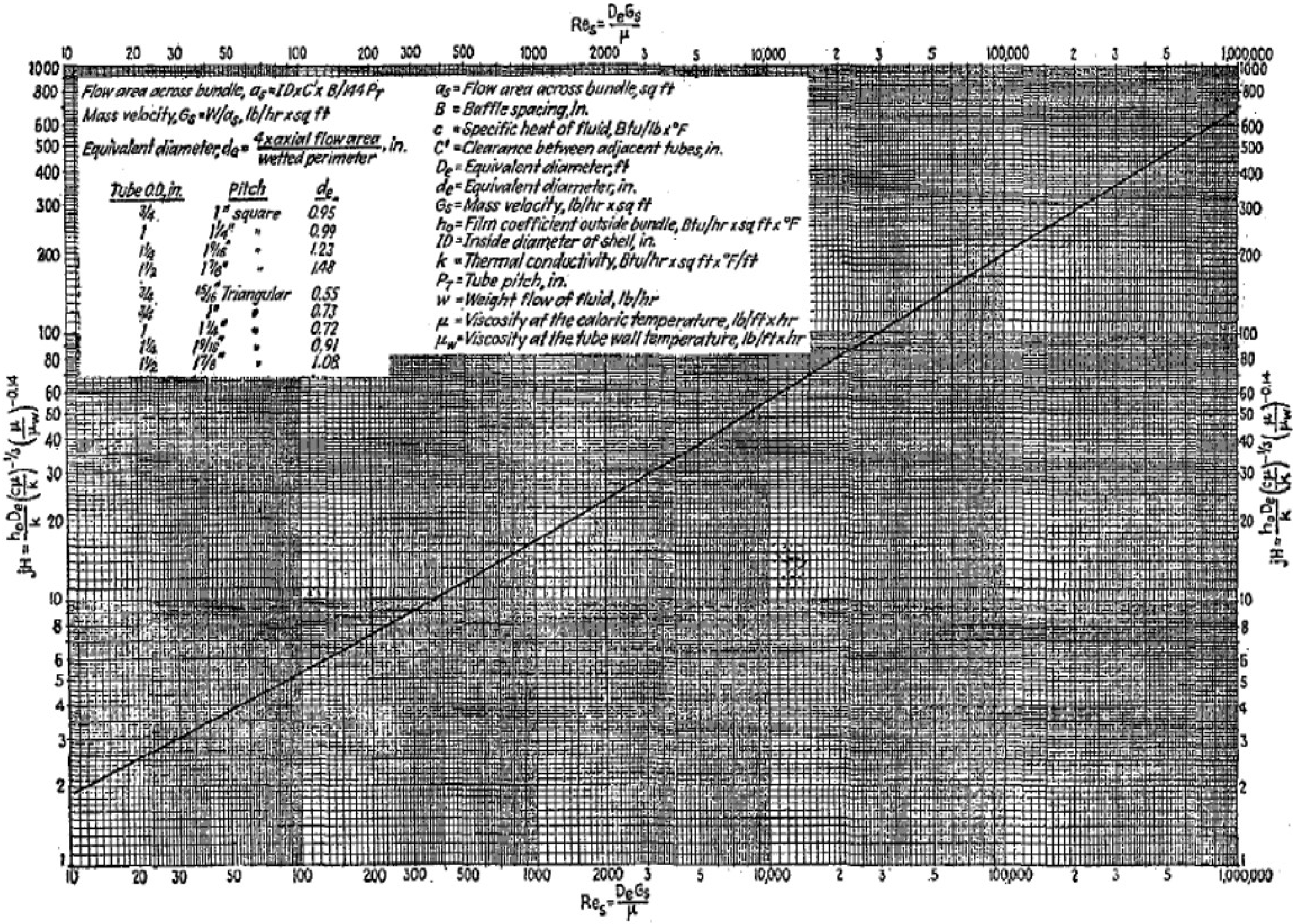


Fig. 24. Tube-side heat-transfer curve. *(Adapted from Sieder and Tate.)*



Flow area across bundle, $a_s = ID \times C' \times B/144\,P_T$

Mass velocity, $G_s = W/a_s$, lb/hr x sq ft

Equivalent diameter, $d_e = \frac{4 \times \text{axial flow area}}{\text{wetted perimeter}}$, in.

Tube O.D., in.	Pitch	d_e
3/4	1" square	0.95
1	1¼" "	0.99
1¼	1$\frac{9}{16}$" "	1.23
1½	1⅞" "	1.48
3/4	$\frac{15}{16}$" Triangular	0.55
3/4	1" "	0.73
1	1¼" "	0.72
1¼	1$\frac{9}{16}$" "	0.91
1½	1⅞" "	1.08

a_s = Flow area across bundle, sq ft
B = Baffle spacing, in.
c = Specific heat of fluid, Btu/lb x °F
C' = Clearance between adjacent tubes, in.
D_e = Equivalent diameter, ft
d_e = Equivalent diameter, in.
G_s = Mass velocity, lb/hr x sq ft
h_o = Film coefficient outside bundle, Btu/hr x sq ft x °F
ID = Inside diameter of shell, in.
k = Thermal conductivity, Btu/hr x sq ft x °F/ft
P_T = Tube pitch, in.
w = Weight flow of fluid, lb/hr
μ = Viscosity at the caloric temperature, lb/ft x hr
μ_w = Viscosity at the tube wall temperature, lb/ft x hr

Fig. 28. Shell-side heat-transfer curve for bundles with 25% cut segmental baffles.