MPE

(20)

M Sc. Eng./PhD(M) **8 May, 2023** (Morning)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Semester Final Examination
Course Code: Math 6103
Course Title: Advanced Mathematics

Summer Semester, A.Y. 2022
Time : 03 hours
Full Marks: 150

There are **8 (Eight)** Questions. Answer any 6 **(Six)** of them. All Questions carry equal Marks. Programmable calculators are not allowed. Do not write on this question paper. The Symbols have their usual meaning.

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1. a) (i) Show that the function $z = e^x \sin y + e^y \cos x$ satisfies the Laplace's equation.

   (ii) Show that the function $u(x,t) = \sin c\omega t \sin \omega x$ satisfies the wave equation $\frac{\partial^2 u}{\partial t^2} = c^2 \frac{\partial^2 u}{\partial x^2}$ for all real values of ω.

   b) Let L(x, y) denote the local linear approximation to $f(x,y) = \sqrt{x^2 + y^2}$ at the point (3, 4). Compare the error in approximating $f(3.04, 3.98)$.

2. a) Find the directional derivative of $f(x, y, z) = x^2y - yz^3 + xy^2z$ at the point (1,−2, 4) in the direction of the vector $\mathbf{a} = 2\mathbf{i} + \mathbf{j} - 2\mathbf{k}$. What is the magnitude and direction of maximum rate of change of $f(x, y, z)$ at this point?

   b) Use a double integral to find the volume of the solid bounded by the cylinder $x^2 + y^2 = 4$ and the planes $y + z = 4$ and $z = 0$.

3. Discuss the basic idea of eigenvalues and eigenvectors. Find the eigenvalues and corresponding eigenvectors of the matrix $A = \begin{bmatrix} 5 & 4 & -1 \\ 4 & 5 & -1 \\ -4 & -4 & 2 \end{bmatrix}$; Is the matrix diagonalizable? If so, find a nonsingular matrix P that diagonalizes A, and write down the corresponding diagonal matrix D.

4. a) Find the volume of the solid enclosed between the circular paraboloid $z = x^2 + y^2$, the right circular cylinder $x^2 + y^2 = 9$, and the xy-plane.

   b) Find a point on the surface $z = 8 - 3x^2 - 2y^2$ at which the tangent plane is perpendicular to the line $x = 2-3t$, $y = 7+8t$, $z = 5-t$. Then write down the equation of the tangent plane..

5. a) For which values of 'a' will the system

$$x + 2y - 3z = 4$$
$$3x - y + 5z = 2$$
$$4x + y + (a^2 - 14)z = a+2$$

have no solutions? Unique solution? Infinitely many solutions?

b) Augmented matrix for a system of linear equations has been reduced to canonical form $\begin{bmatrix} 1 & 0 & 0 & 4 & -1 \\ 0 & 1 & 0 & 2 & 6 \\ 0 & 0 & 1 & 3 & 2 \end{bmatrix}$ by row operations. Solve the system.

6. Solve the following boundary value problem by the method of separation of variables.

$$\frac{\partial u}{\partial t} = 2\frac{\partial^2 u}{\partial x^2} \;;\; 0 < x < 3 \;,\; t > 0, \text{ given that } u(0,t) = u(3,t) = 0$$
$$u(x,0) = 5\sin 4\pi x - 3\sin 8\pi x + 2\sin 10\pi x \;,\quad |u(x,t)| < M.$$

7. A circular plate of unit radius, whose faces are insulated, has half of its boundary kept at constant temperature u_1 and the other half at constant temperature u_2. Find the steady state temperature of the plate.

8. (i) Find the gravitational potential at any point on the axis of a thin uniform ring of radius a. (ii) Find potential of the ring at any point in the space.

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MCE 6153 Data sheet

Eqn. No.	Correlation	Remarks
(10-7)	$dQ = h_{fg}\, dm$	Heat Transfer rate
(10-10)	$\delta(x) = \left[\frac{4\mu_l k_l (T_v - T_w) x}{g(\rho_l - \rho_v)\rho_l h_{fg}}\right]^{1/4}$	Thickness of condensate film on a vertical plate for laminar film condensation
(10-11)	$h_x = \frac{k_l}{\delta(x)}$	Local Heat Transfer Coefficient using condensate thickness.
(10-12)	$h_x = \left[\frac{g\rho_l(\rho_l - \rho_v) h_{fg} k_l^3}{4\mu_l (T_v - T_w) x}\right]^{1/4}$	Local Heat Transfer Coefficient
(10-15)	$h_m = 0.943\left[\frac{g\rho_l(\rho_l - \rho_v) h_{fg} k_l^3}{\mu_l (T_v - T_w) L}\right]^{1/4}$	Theoretical Average Heat Transfer Coefficient for vertical plate.
(10-18)	$h_m = 0.943\left[\frac{g\rho_l(\rho_l - \rho_v) h_{fg} k_l^3}{\mu_l (T_v - T_w) L}\sin\varphi\right]^{1/4}$	Average Heat Transfer Coefficient for vertical plate for inclined surfaces where φ is the angle with the horizontal.
(10-19)	$h_m = 0.725\left[\frac{g\rho_l(\rho_l - \rho_v) h_{fg} k_l^3}{\mu_l (T_v - T_w) D}\right]^{1/4}$	Average Heat Transfer Coefficient on horizontal tube for laminar film condensation.
(10-20)	$h_m\Big\|_{N\ \text{tubes}} = 0.725\left[\frac{g\rho_l(\rho_l - \rho_v) h_{fg} k_l^3}{\mu_l (T_v - T_w) N D}\right]^{1/4} = \frac{1}{N^{1/4}}[h_m]_{1\ \text{tube}}$	Average Heat Transfer Coefficient on horizontal tube banks for N tubes.
(10-24)	$\mathrm{Re} = \frac{4M}{\mu_l P}$	Reynolds number at the lowest part for condensate flow.
(10-25)	$P = \begin{cases} \pi D & \text{for vertical tube of outside diameter } D \quad (10\text{-}25a) \\ 2L & \text{for horizontal tube of length } L \quad (10\text{-}25b) \\ w & \text{for vertical or inclined plate of width } w \quad (10\text{-}25c) \end{cases}$	Geometry depended wetted perimeter P.

Eqn. No.	Correlation	Remarks
(10-27*a*)	$h_m = 1.13\left[\frac{g\rho_l^2 h_{fg} k_l^3}{\mu_l(T_v - T_w)L}\right]^{1/4}$	Average heat transfer coefficient for laminar film condensation on a vertical surface
	or	$\rho_v \ll \rho_l$
(10-27*b*)	$h_m\left(\frac{\mu_l^2}{k_l^3\rho_l^2 g}\right)^{1/3} = 1.76\ \mathrm{Re}^{-1/3}$	Re < 1800
(10-28)	$h_m\left(\frac{\mu_l^2}{k_l^3\rho_l^2 g}\right)^{1/3} = 0.0077\ \mathrm{Re}^{0.4}$	Average heat transfer coefficient on a vertical surface for turbulent film condensation $\rho_v \ll \rho_l$ Re > 1800
(10-29*a*)	$h_m = 0.555\left[\frac{g\rho_l(\rho_l - \rho_v)k_l^3 h'_{fg}}{\mu_l(T_{sat} - T_w)D}\right]^{1/4}$	Film condensation inside horizontal tubes at low vapor velocities $\mathrm{Re}_v = \frac{\rho_v u_v D}{\mu_v} < 35{,}000$
(10-29*b*)	where $h'_{fg} \equiv h_{fg} + \frac{3}{8}c_{pl}(T_v - T_w)$	
(10-31)	$\frac{h_m D}{k_l} = 0.026\ \mathrm{Pr}_l^{1/3}\left[\mathrm{Re}_l + \mathrm{Re}_v\left(\frac{\rho_l}{\rho_v}\right)^{1/2}\right]^{0.8}$	Film condensation inside horizontal tubes at higher flow rates
(10-34	$\frac{c_{pl}\Delta T}{h_{fg}\mathrm{Pr}_l^n} = C_{sf}\left[\frac{q}{\mu_l h_{fg}}\sqrt{\frac{g_c\sigma^*}{g(\rho_l - \rho_v)}}\right]^{0.33}$	Heat flux in nucleata pool boiling; coefficient C_{sf} is given in Table 10-1; $n = 1$ for water, $n = 1.7$ for other liquids
(10-36)	$q_{max} = F(L') \times 0.131\rho_v^{1/2}h_{fg}[\sigma^* g g_c(\rho_l - \rho_v)]^{1/4}$	Maximum heat flux in pool boiling; factor $F(L')$ is for effects of heater geometry and is given in Table 10-3
(10-37)	$L' = L\sqrt{\frac{g(\rho_l - \rho_v)}{\sigma^*}}$	
(10-38)	$h_0 = 0.62\left[\frac{k_v^3\rho_v(\rho_l - \rho_v)gh_{fg}}{\mu_v D_o\Delta T}\left(1 + \frac{0.4c_{pv}\Delta T}{h_{fg}}\right)\right]^{1/4}$	Heat transfer coefficient for stable film boiling without radiation effects

Heat transfer coefficient for stable film boiling with radiation effects

$$h_r = \frac{1}{1/\varepsilon + 1/\alpha - 1}\,\frac{\sigma(T_w^4 - T_s^4)}{T_w - T_s} \qquad (10\text{-}39b)$$

$$h_m = h_0 + \tfrac{3}{4}h_r \qquad (10\text{-}40)$$

The physical properties of vapor evaluated at $T_f = \frac{1}{2}(T_w + T_s) = \frac{1}{2}(750 + 100) = 425°C$ are taken as

$c_{pv} = 2085$ J/(kg · °C) $\qquad k_v = 0.0505$ W/(m · °C)

$\mu_v = 24.26 \times 10^{-6}$ kg/(m · s) $\qquad \rho_v = 0.314$ kg/m³

The liquid density and h_{fg} are evaluated at the saturation temperature T_s:

$\rho_l = 960.6$ kg/m³ $\qquad h_{fg} = 2257 \times 10^3$ J/kg

Two-phase heat transfer coefficient h_{TP} for boiling in forced-convection regime inside circular tubes; F and S obtained from Figs. 10-12 and 10-13, respectively

$$h_{TP} = h_{NB} + h_c \qquad (10\text{-}43)$$

$$h_c = 0.023\left(\frac{k_l}{D}\right)\mathrm{Re}_l^{0.8}\,\mathrm{Pr}_l^{0.4}\,F \qquad (10\text{-}44)$$

$$G = \frac{\text{mass flow rate through tube}}{A_{\text{tube}}},\ \mathrm{kg/(m^2 \cdot s)}$$

$$\mathrm{Re}_l = \frac{G(1-x)D}{\mu_l}$$

$$h_{NB} = 0.00122\left(\frac{k_l^{0.79}c_{pl}^{0.45}\rho_l^{0.49}}{\sigma^{*0.5}\mu_l^{0.29}h_{fg}^{0.24}\rho_v^{0.24}}\right)\Delta T_{\text{sat}}^{0.24}\cdot\Delta P_{\text{sat}}^{0.75}\cdot S \qquad (10\text{-}45)$$

$$\mathrm{Re}_{TP} = F^{1.25}\,\mathrm{Re}_l = F^{1.25}\left[\frac{G(1-x)D}{\mu_l}\right] \qquad (10\text{-}46)$$

The Martinelli parameter X_{tt} appearing in Fig. 10-12 is defined as

$$X_{tt} = \left(\frac{1-x}{x}\right)^{0.9}\left(\frac{\rho_v}{\rho_l}\right)^{0.5}\left(\frac{\mu_l}{\mu_v}\right)^{0.1} \qquad (10\text{-}47)$$

$$q = h_{TP}\,\Delta T_{\text{sat}} = h_{TP}(T_w - T_{\text{sat}}) \qquad (10\text{-}48)$$

Table 10-3 Correction factor $F(L')$ for use in Eq. (10-36)

Heater geometry	$F(L')$	Remarks
1. Infinite flat plate facing up	1.14	$L' \geq 2.7$; L is the heater width or diameter
2. Horizontal cylinder	$0.89 + 2.27e^{-3.44\sqrt{L'}}$	$L' \geq 0.15$; L is the cylinder radius
3. Large sphere	0.84	$L' \geq 4.26$; L is the sphere radius
4. Small sphere	$\frac{1.734}{(L')^{1/2}}$	$0.15 \leq L' \leq 4.26$; L is the sphere radius
5. Large finite body	~0.90	$L' \gtrsim 4$; $L = \frac{\text{volume}}{\text{surface area}}$

Table 10-1 Values of the coefficient $C_{s,f}$ of Eq. (10-34) for various liquid-surface combinations

Liquid-surface combination	$C_{s,f}$	Reference
Water–copper	0.0130	[75]
Water–scored copper	0.0068	[74]
Water–emergy-polished copper	0.0128	[74]
Water–emery-polished, paraffin-treated copper	0.0147	[74]
Water–chemically etched stainless steel	0.0133	[74]
Water–mechanically polished stainless steel	0.0132	[74]
Water–ground and polished stainless steel	0.0080	[74]
Water–Teflon pitted stainless steel	0.0058	[74]
Water–platinum	0.0130	[71]
Water–brass	0.0060	[74]
Benzene–chromium	0.0100	[70]
Ethyl alcohol–chromium	0.0027	[70]
Carbon tetrachlc ide–copper	0.0130	[75]
Carbon tetra[illegible] ide–emery-polished copper	0.0070	[74]
n-Pentane–emery-polished copper	0.0154	[74]
n-Pentane–emergy-polished nickel	0.0127	[74]
n-Pentane–emery-rubber copper	0.0074	[74]
n-Pentane–lapped copper	0.0049	[74]

Table 10-2 Values of liquid-vapor surface tension σ for various liquids

	Saturation temperature		Surface tension	
Liquid	°F	°C	$\sigma^* \times 10^4$ lbf/ft	$\sigma^* \times 10^3$ N/m
Water	32	0	51.8	75.6
Water	60	15.56	50.2	73.2
Water	100	37.78	47.8	69.7
Water	200	93.34	41.2	60.1
Water	212	100	40.3	58.8
Water	320	160	31.6	46.1
Water	440	226.7	21.9	31.9
Water	560	293.3	11.1	16.2
Water	680	360	1.0	1.46
Water	705.4	374.11	0.0	0
Sodium	1618	881.1	77	11.2
Potassium	1400	760	43	62.7
Rubidium	1270	687.8	30	43.8
Cesium	1260	682.2	20	29.2
Mercury	675	357.2	27	39.4
Benzene (C_6H_6)	176	80	19	27.7
Ethyl alcohol (C_2H_6O)	173	78.3	15	21.9
Freon 11	112	44.4	5.8	8.5

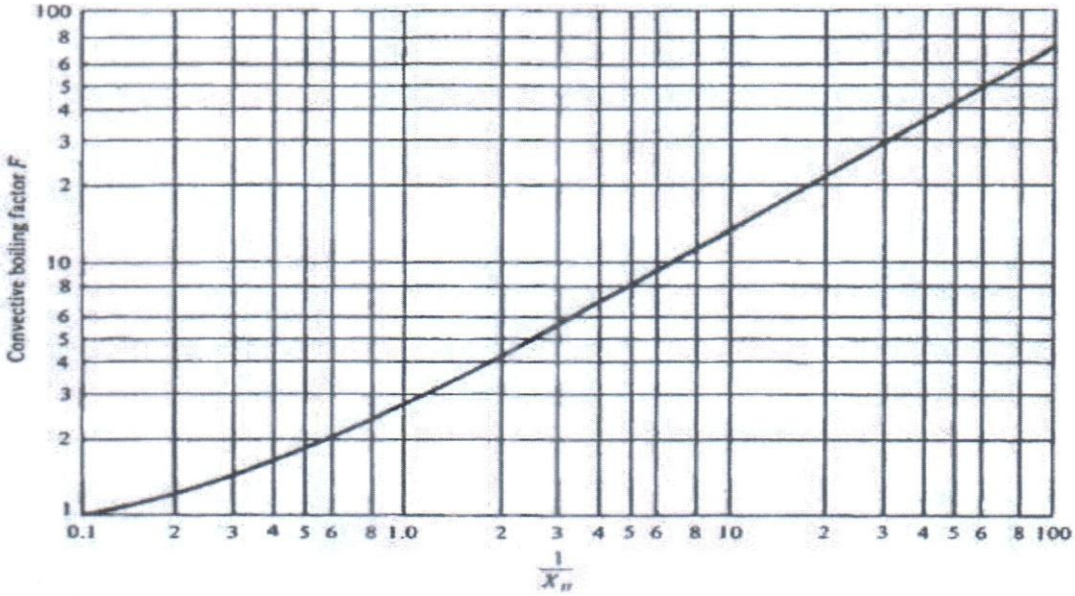

Figure 10-12 Convective boiling factor F.

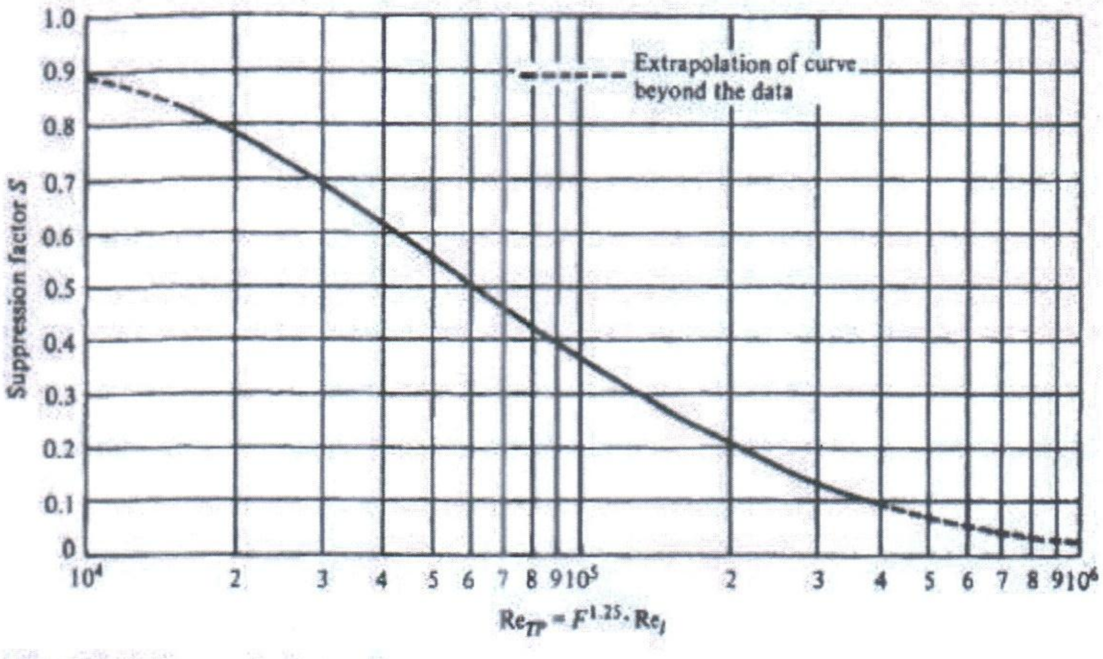

Figure 10-13 Suppression factor S.

TABLE A-9

Properties of saturated water

Temp. T, °C	Saturation Pressure P_{sat}, kPa	Density ρ, kg/m³ Liquid	Density ρ, kg/m³ Vapor	Enthalpy of Vaporization h_{fg}, kJ/kg	Specific Heat c_p, J/kg · K Liquid	Specific Heat c_p, J/kg · K Vapor	Thermal Conductivity k, W/m · K Liquid	Thermal Conductivity k, W/m · K Vapor	Dynamic Viscosity μ, kg/m · s Liquid	Dynamic Viscosity μ, kg/m · s Vapor	Prandtl Number Pr Liquid	Prandtl Number Pr Vapor	Volume Expansion Coefficient β, 1/K Liquid
0.01	0.6113	999.8	0.0048	2501	4217	1854	0.561	0.0171	1.792×10^{-3}	0.922×10^{-5}	13.5	1.00	-0.068×10^{-3}
5	0.8721	999.9	0.0068	2490	4205	1857	0.571	0.0173	1.519×10^{-3}	0.934×10^{-5}	11.2	1.00	0.015×10^{-3}
10	1.2276	999.7	0.0094	2478	4194	1862	0.580	0.0176	1.307×10^{-3}	0.946×10^{-5}	9.45	1.00	0.733×10^{-3}
15	1.7051	999.1	0.0128	2466	4185	1863	0.589	0.0179	1.138×10^{-3}	0.959×10^{-5}	8.09	1.00	0.138×10^{-3}
20	2.339	998.0	0.0173	2454	4182	1867	0.598	0.0182	1.002×10^{-3}	0.973×10^{-5}	7.01	1.00	0.195×10^{-3}
25	3.169	997.0	0.0231	2442	4180	1870	0.607	0.0186	0.891×10^{-3}	0.987×10^{-5}	6.14	1.00	0.247×10^{-3}
30	4.246	996.0	0.0304	2431	4178	1875	0.615	0.0189	0.798×10^{-3}	1.001×10^{-5}	5.42	1.00	0.294×10^{-3}
35	5.628	994.0	0.0397	2419	4178	1880	0.623	0.0192	0.720×10^{-3}	1.016×10^{-5}	4.83	1.00	0.337×10^{-3}
40	7.384	992.1	0.0512	2407	4179	1885	0.631	0.0196	0.653×10^{-3}	1.031×10^{-5}	4.32	1.00	0.377×10^{-3}
45	9.593	990.1	0.0655	2395	4180	1892	0.637	0.0200	0.596×10^{-3}	1.046×10^{-5}	3.91	1.00	0.415×10^{-3}
50	12.35	988.1	0.0831	2383	4181	1900	0.644	0.0204	0.547×10^{-3}	1.062×10^{-5}	3.55	1.00	0.451×10^{-3}
55	15.76	985.2	0.1045	2371	4183	1908	0.649	0.0208	0.504×10^{-3}	1.077×10^{-5}	3.25	1.00	0.484×10^{-3}
60	19.94	983.3	0.1304	2359	4185	1916	0.654	0.0212	0.467×10^{-3}	1.093×10^{-5}	2.99	1.00	0.517×10^{-3}
65	25.03	980.4	0.1614	2346	4187	1926	0.659	0.0216	0.433×10^{-3}	1.110×10^{-5}	2.75	1.00	0.548×10^{-3}
70	31.19	977.5	0.1983	2334	4190	1936	0.663	0.0221	0.404×10^{-3}	1.126×10^{-5}	2.55	1.00	0.578×10^{-3}
75	38.58	974.7	0.2421	2321	4193	1948	0.667	0.0225	0.378×10^{-3}	1.142×10^{-5}	2.38	1.00	0.607×10^{-3}
80	47.39	971.8	0.2935	2309	4197	1962	0.670	0.0230	0.355×10^{-3}	1.159×10^{-5}	2.22	1.00	0.653×10^{-3}
85	57.83	968.1	0.3536	2296	4201	1977	0.673	0.0235	0.333×10^{-3}	1.176×10^{-5}	2.08	1.00	0.670×10^{-3}
90	70.14	965.3	0.4235	2283	4206	1993	0.675	0.0240	0.315×10^{-3}	1.193×10^{-5}	1.96	1.00	0.702×10^{-3}
95	84.55	961.5	0.5045	2270	4212	2010	0.677	0.0246	0.297×10^{-3}	1.210×10^{-5}	1.85	1.00	0.716×10^{-3}
100	101.33	957.9	0.5978	2257	4217	2029	0.679	0.0251	0.282×10^{-3}	1.227×10^{-5}	1.75	1.00	0.750×10^{-3}
110	143.27	950.6	0.8263	2230	4229	2071	0.682	0.0262	0.255×10^{-3}	1.261×10^{-5}	1.58	1.00	0.798×10^{-3}
120	198.53	943.4	1.121	2203	4244	2120	0.683	0.0275	0.232×10^{-3}	1.296×10^{-5}	1.44	1.00	0.858×10^{-3}
130	270.1	934.6	1.496	2174	4263	2177	0.684	0.0288	0.213×10^{-3}	1.330×10^{-5}	1.33	1.01	0.913×10^{-3}
140	361.3	921.7	1.965	2145	4286	2244	0.683	0.0301	0.197×10^{-3}	1.365×10^{-5}	1.24	1.02	0.970×10^{-3}
150	475.8	916.6	2.546	2114	4311	2314	0.682	0.0316	0.183×10^{-3}	1.399×10^{-5}	1.16	1.02	1.025×10^{-3}
160	617.8	907.4	3.256	2083	4340	2420	0.680	0.0331	0.170×10^{-3}	1.434×10^{-5}	1.09	1.05	1.145×10^{-3}
170	791.7	897.7	4.119	2050	4370	2490	0.677	0.0347	0.160×10^{-3}	1.468×10^{-5}	1.03	1.05	1.178×10^{-3}
180	1,002.1	887.3	5.153	2015	4410	2590	0.673	0.0364	0.150×10^{-3}	1.502×10^{-5}	0.983	1.07	1.210×10^{-3}
190	1,254.4	876.4	6.388	1979	4460	2710	0.669	0.0382	0.142×10^{-3}	1.537×10^{-5}	0.947	1.09	1.280×10^{-3}
200	1,553.8	864.3	7.852	1941	4500	2840	0.663	0.0401	0.134×10^{-3}	1.571×10^{-5}	0.910	1.11	1.350×10^{-3}
220	2,318	840.3	11.60	1859	4610	3110	0.650	0.0442	0.122×10^{-3}	1.641×10^{-5}	0.865	1.15	1.520×10^{-3}
240	3,344	813.7	16.73	1767	4760	3520	0.632	0.0487	0.111×10^{-3}	1.712×10^{-5}	0.836	1.24	1.720×10^{-3}
260	4,688	783.7	23.69	1663	4970	4070	0.609	0.0540	0.102×10^{-3}	1.788×10^{-5}	0.832	1.35	2.000×10^{-3}
280	6,412	750.8	33.15	1544	5280	4835	0.581	0.0605	0.094×10^{-3}	1.870×10^{-5}	0.854	1.49	2.380×10^{-3}
300	8,581	713.8	46.15	1405	5750	5980	0.548	0.0695	0.086×10^{-3}	1.965×10^{-5}	0.902	1.69	2.950×10^{-3}
320	11,274	667.1	64.57	1239	6540	7900	0.509	0.0836	0.078×10^{-3}	2.084×10^{-5}	1.00	1.97	
340	14,586	610.5	92.62	1028	8240	11,870	0.469	0.110	0.070×10^{-3}	2.255×10^{-5}	1.23	2.43	
360	18,651	528.3	144.0	720	14,690	25,800	0.427	0.178	0.060×10^{-3}	2.571×10^{-5}	2.06	3.73	
374.14	22,090	317.0	317.0	0	—	—	—	—	0.043×10^{-3}	4.313×10^{-5}			

Freon 12 Saturation Properties — Temperature Table

Temp °C	Pressure [kPa]	Volume [m³/kg]		Density [kg/m³]		Enthalpy [kJ/kg]			Entropy [kJ/K-kg]		Temp °C
		Liquid v_f	Vapour v_g	Liquid d_f	Vapour d_g	Liquid H_f	Latent H_{fg}	Vapour H_g	Liquid S_f	Vapour S_g	
-20	150.7	0.0007	0.1098	1458.0	9.109	181.6	162.1	343.7	0.9305	1.5710	-20
-19	156.7	0.0007	0.1059	1455.0	9.446	182.5	161.6	344.1	0.9341	1.5700	-19
-18	162.8	0.0007	0.1021	1452.0	9.792	183.4	161.2	344.6	0.9376	1.5690	-18
-17	169.1	0.0007	0.0986	1449.0	10.150	184.3	160.8	345.1	0.9412	1.5690	-17
-16	175.6	0.0007	0.0951	1446.0	10.510	185.2	160.3	345.5	0.9447	1.5680	-16
-15	182.3	0.0007	0.0918	1443.0	10.890	186.1	159.9	346.0	0.9482	1.5670	-15
-14	189.2	0.0007	0.0887	1440.0	11.270	187.1	159.3	346.4	0.9517	1.5670	-14
-13	196.3	0.0007	0.0857	1437.0	11.670	188.0	158.9	346.9	0.9552	1.5660	-13
-12	203.6	0.0007	0.0828	1434.0	12.080	188.9	158.5	347.4	0.9587	1.5660	-12
-11	211.1	0.0007	0.0800	1431.0	12.500	189.8	158.0	347.8	0.9622	1.5650	-11
-10	218.8	0.0007	0.0774	1428.0	12.920	190.7	157.6	348.3	0.9656	1.5640	-10
-9	226.7	0.0007	0.0748	1425.0	13.370	191.6	157.1	348.7	0.9691	1.5640	-9
-8	234.8	0.0007	0.0724	1421.0	13.820	192.6	156.6	349.2	0.9726	1.5630	-8
-7	243.2	0.0007	0.0700	1418.0	14.280	193.5	156.2	349.7	0.9760	1.5630	-7
-6	251.8	0.0007	0.0678	1415.0	14.760	194.4	155.7	350.1	0.9795	1.5620	-6
-5	260.6	0.0007	0.0656	1412.0	15.240	195.3	155.3	350.6	0.9829	1.5620	-5
-4	269.6	0.0007	0.0635	1409.0	15.740	196.3	154.7	351.0	0.9863	1.5610	-4
-3	278.9	0.0007	0.0615	1406.0	16.260	197.2	154.3	351.5	0.9898	1.5610	-3
-2	288.4	0.0007	0.0596	1402.0	16.780	198.1	153.8	351.9	0.9932	1.5600	-2
-1	298.1	0.0007	0.0577	1399.0	17.320	199.1	153.3	352.4	0.9966	1.5600	-1
0	308.1	0.0007	0.0560	1396.0	17.870	200.0	152.8	352.8	1.0000	1.5590	0
1	318.4	0.0007	0.0542	1393.0	18.440	200.9	152.4	353.3	1.0030	1.5590	1
2	328.9	0.0007	0.0526	1390.0	19.020	201.9	151.8	353.7	1.0070	1.5590	2
3	339.7	0.0007	0.0510	1386.0	19.610	202.8	151.3	354.1	1.0100	1.5580	3
4	350.7	0.0007	0.0495	1383.0	20.220	203.8	150.8	354.6	1.0140	1.5580	4
5	362.0	0.0007	0.0480	1380.0	20.840	204.7	150.3	355.0	1.0170	1.5570	5
6	373.6	0.0007	0.0466	1377.0	21.480	205.7	149.7	355.4	1.0200	1.5570	6
7	385.4	0.0007	0.0452	1373.0	22.130	206.6	149.3	355.9	1.0240	1.5570	7