MADE EASY

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ESE 2025 : Mains Test Series

UPSC ENGINEERING SERVICES EXAMINATION

Mechanical Engineering

Test-3 : Fluid Mechanics + Fluid Machinery + Power Plant

Name : ....

Roll No :

Test Centres			Student's Signature
Delhi ☑	Bhopal ☐	Jaipur ☐	
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Instructions for Candidates

1. Do furnish the appropriate details in the answer sheet (viz. Name & Roll No).
2. There are Eight questions divided in TWO sections.
3. Candidate has to attempt FIVE questions in all in English only.
4. Question no. 1 and 5 are compulsory and out of the remaining THREE are to be attempted choosing at least ONE question from each section.
5. Use only black/blue pen.
6. The space limit for every part of the question is specified in this Question Cum Answer Booklet. Candidate should write the answer in the space provided.
7. Any page or portion of the page left blank in the Question Cum Answer Booklet must be clearly struck off.
8. There are few rough work sheets at the end of this booklet. Strike off these pages after completion of the examination.

FOR OFFICE USE

Question No.	Marks Obtained
Section-A	
Q.1	40
Q.2	—
Q.3	—
Q.4	48
Section-B	
Q.5	17
Q.6	08
Q.7	24
Q.8	—
Total Marks Obtained	137

Signature of Evaluator: Gaurav Sharma ....

Cross Checked by ....

IMPORTANT INSTRUCTIONS

CANDIDATES SHOULD READ THE UNDERMENTIONED INSTRUCTIONS CAREFULLY. VIOLATION OF ANY OF THE INSTRUCTIONS MAY LEAD TO PENALTY.

DONT'S

1. Do not write your name or registration number anywhere inside this Question-cum-Answer Booklet (QCAB).
2. Do not write anything other than the actual answers to the questions anywhere inside your QCAB.
3. Do not tear off any leaves from your QCAB, if you find any page missing do not fail to notify the supervisor/invigilator.
4. Do not leave behind your QCAB on your table unattended, it should be handed over to the invigilator after conclusion of the exam.

DO'S

1. Read the Instructions on the cover page and strictly follow them.
2. Write your registration number and other particulars, in the space provided on the cover of QCAB.
3. Write legibly and neatly.
4. For rough notes or calculation, the last two blank pages of this booklet should be used. The rough notes should be crossed through afterwards.
5. If you wish to cancel any work, draw your pen through it or write "Cancelled" across it, otherwise it may be evaluated.
6. Handover your QCAB personally to the invigilator before leaving the examination hall.

Section A : Fluid Mechanics + Fluid Machinery + Power Plant

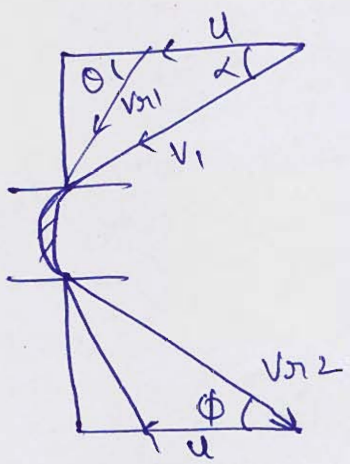
Q.1 (a) An impulse turbine has nozzle inclined to 25° to the plane of rotation. The inlet and exit angle of the moving blades are equal, the blade friction factor is 0.8 and the mean diameter of the blade is 0.6 m. The steam leaves the nozzle with a velocity of 780 m/s. Determine the optimum value of the blade angles, the steam flow rate required to produce 20 kW power and the blade efficiency.

[12 marks]

$\alpha = 25^0$

$\theta = \phi$ $K = 0.8$ $D_m = 0.6\,m$ $V_1 = 780\,m/s$.

$P = 20\,KW$ $\dot{m}_s = ?$ $\theta = \phi = ?$.



$W.D = \dot{m}(V_{w1} + V_{w2})u$.

we know that for max. work done

$\rho = \frac{u}{V_1} = \frac{\cos\alpha}{2}$.

$u = 353.46\,m/s$.

$\tan\theta = \frac{(V_{f1})}{(V_{w1} - u)}$

$V_{w1} = V_1\cos\alpha = 706.92\,m/s$

$V_{f1} = V_1\sin\alpha = 329.46\,m/s$.

$\theta = 43.04^0$

$\therefore \boxed{\theta = \phi = 43.04^0}$ inlet and exit Blade angles.

$(\eta_{blade})_{opt} = \frac{\cos^2\alpha}{2}(1 + Kx)$ $x = \frac{\cos\phi}{\cos\alpha}$

$\boxed{\eta_{blade} = 73.925\%}$

$20KW = \dot{m}_s\left(\frac{V_1^2}{2}\right)(\eta_{blade})$.

$\dot{m}_s = 0.08893$ kg/s → Steam flow Rate.

8

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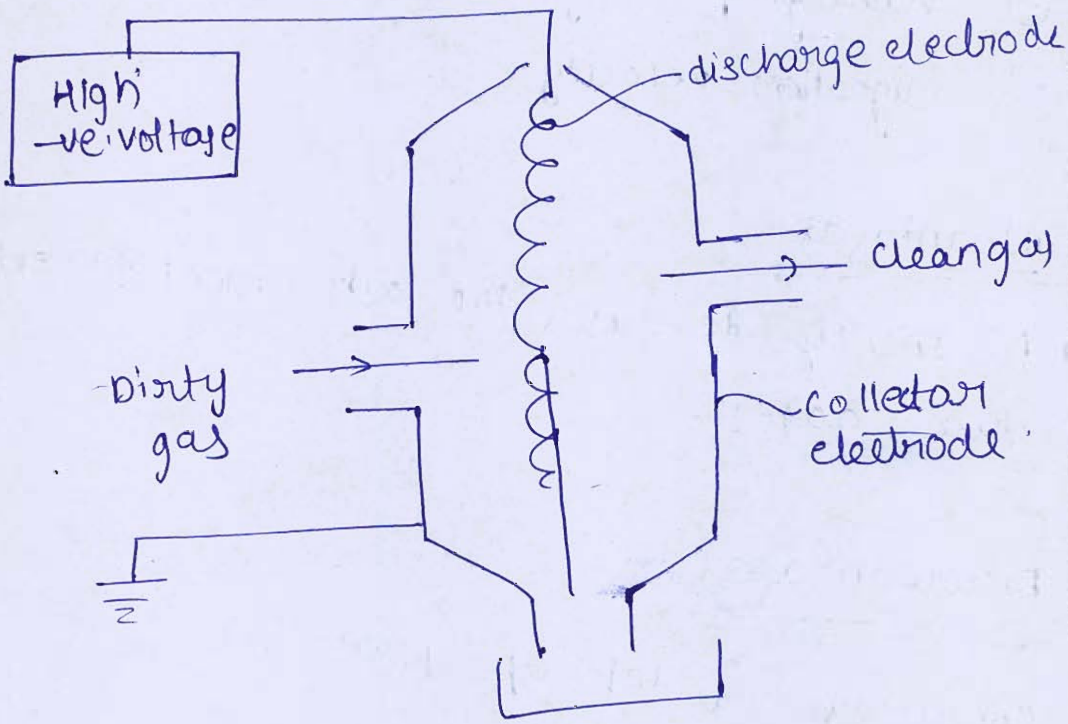
Q.1 (b) Explain the working principle of a Electrostatic Precipitator (ESP) with the help of a neat and schematic diagram. Describe the main components of an ESP and their functions. Also, discuss the various factors that influence the performance of an ESP, and highlight the key advantages and disadvantages of using ESP.

[12 marks]



Due to high negative voltage near discharge electrode air gets ionised forming +ve and negative ions. These ions strike with fly ash particles making them -vely charged. These charged ash particles accelerate towards collector electrodes and loose their charge.

periodic rammering of collector electrode is required.

Performance of ESP is affected by.

① collector area.
② velocity of fluegases.
③ migration velocity

Advantages

1. Drastically decreases the ash content in exhaust flue gases.

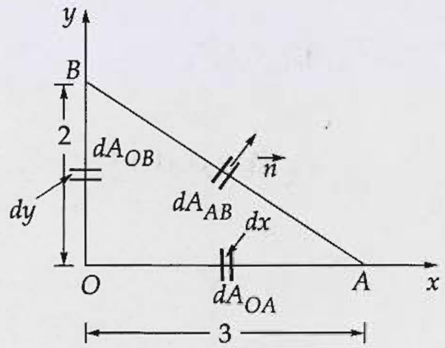
Disadvantages

consumes a lot of power.

.1 (c) A stream function is given by

$\psi = 3x^2y + 4(2+t)y^2$

Find the flow rates across the faces of the triangular prism *OAB* shown in the figure, having a thickness of 1 unit in the *z*-direction at time $t = 2$.



[12 marks]

$u = -\frac{\partial \psi}{\partial y} = -\left[3x^2 + 4(2+t)(2y)\right].$

$V = \frac{\partial \psi}{\partial x} = 6xy$

at $t = 2$

$u = -\left[3x^2 + 32y\right].$

$V = 6xy.$

FACE OA

$Q_{OA} = 0$

$Q_{OA} = \int V \cdot dA.$ {y = 0 along OA}.

$= \int_0^3 6xy\,(1 \times dx) = 0$

FACE

$Q_{OB} = \int_{y=0}^{y=2} V\,(1 \times dy)$ {x = 0 along OB}

$= \int_0^2 (\cancel{3x^2}^{\,0} + 32y)\,dy$

$= 32 \frac{y^2}{2} \Big]_0^2 = 64$ units

$Q_{AB} = Q_{OA} + Q_{OB}$

$Q_{OA} = 0$

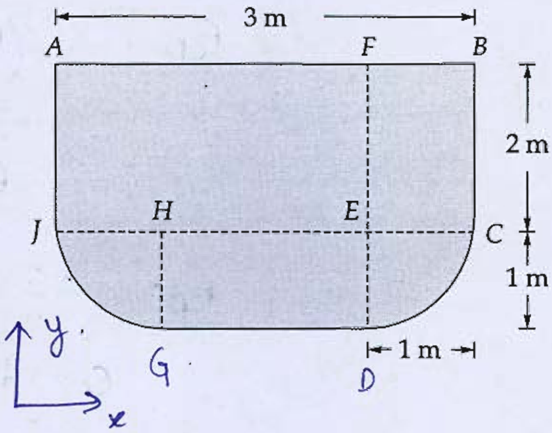
$Q_{OB} = 64$ units

$Q_{AB} = 64$ units.

12

Q.1 (d) A container of geometry shown in figure contains a liquid of specific gravity 0.7 upto depth of 3 m. Determine the magnitude and direction of hydrostatic pressure force per unit length of container exerted on its vertical *BC*, curved corner *CD* and horizontal bottom *DG*.

[12 marks]



$\rho = 700\ kg/m^3$.

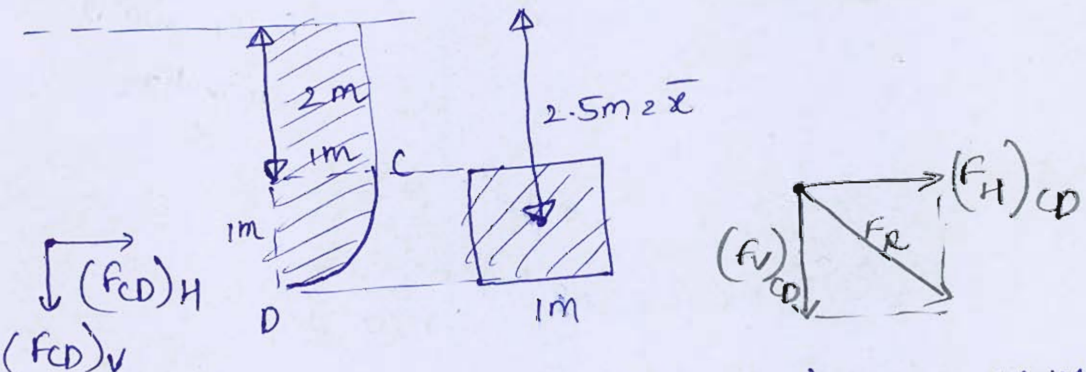
on vertical BC

$F_{BC} = (\rho g \bar{x}) A$

$= 700 \times 9.81 \times 1 \times 2 \times 1$

$F_{BC} = 13.734\ kN$ in positive x direction

on curved corner CD



$(F_{CD})_H = (700 \times 9.81 \times 2.5) \times (1 \times 1) = 17.16\ kN$.

$(F_{CD})_V =$ wt of water above curved surface upto free surface

$= \rho g V$

$= 700 \times 9.81 \times \left[(2 \times 1) + \frac{\pi(1^2)}{4}\right] \times 1$

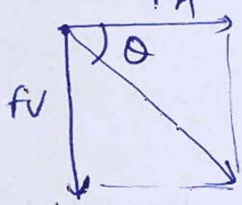
$(F_{CD})_V = 19.127\ kN$.

$$F_{CD} = \sqrt{(F_H)_{CD}^2 + (F_V)_{CD}^2}$$

$$= \sqrt{660.31}$$

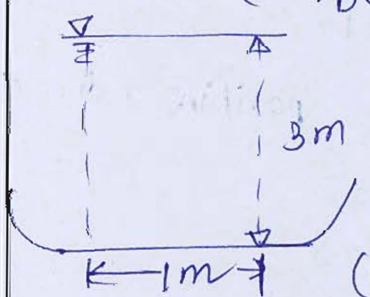
$F_{CD} = 25.69$ kN.

$\theta = 48.1^\circ$



on Horizontal Bottom DG

$(F_V)_{DG}$ = wt of water above DG up to freesurface



$= 700 \times 9.81 \times (1 \times 1 \times 3)$

$(F_V)_{DG} = 20.6$ kN. } Force on DG in vertically Down ward direction.

12

Q.1 (e) A centrifugal pump lifts water under a static head of 50 m of which 4 m is suction lift. The suction and delivery pipes are both of 37 cm diameter. The friction loss in suction pipe is 2.5 m and in delivery pipe it is 7 m. The impeller is 0.6 m in diameter and 3.3 cm wide at outlet and runs at a speed of 1250 rpm. The exit blade angle is 20°. If the manometric efficiency of the pump is 85%. Determine the pressures at the suction and delivery ends of the pump and the discharge (assume the flow to be radial at the inlet).

[12 marks]

$H_S = 50 m$ $\quad$ $H_{fS} = 2.5 m$

$h_S = 4 m$ $\quad$ $H_{fD} = 7 m$

$H_m = H_S + H_f$

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Q.2 (a) In a reheat cy.cle, steam at 500°C expands in a H.P. turbine till it is saturated vapour. It is then reheated upto a temperature of 400°C and then expands in the L.P. turbine to 50°C. If the maximum moisture content of the turbine exhaust is limited to 18%. Determine

(i) the reheat pressure

(ii) the boiler pressure

(iii) the net specific work output

(iv) the cycle efficiency

(v) the steam rate

Assume all process are ideal.

[Use Steam Tables attached at the end]

[20 marks]

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Q.2 (b) A solid hemisphere of density ρ and radius r floats with its plane base immersed in a liquid of density $\rho_l (\rho_l > \rho)$. Show that the equilibrium is stable and the metacentric height is

$$\frac{3}{8}r\left(\frac{\rho_l}{\rho}-1\right)$$

[20 marks]

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Q.2 (c) A turbo-jet engine consumes air at the rate of 50 kg/s when flying at a speed of 1800 km/h. Calculate

(i) Exit velocity of the jet when the enthalpy change for the nozzle is 300 kJ/kg and velocity coefficient is 0.96.

(ii) Fuel flow rate is kg/s when air-fuel ratio is 70 : 1.

(iii) Thrust specific fuel consumption.

(iv) Thermal efficiency of the plant when the combustion efficiency is 95% and calorific value f fuel used is 42000 kJ/kg.

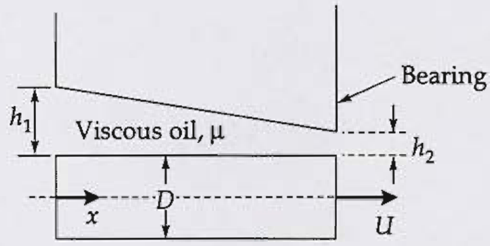
(v) Propulsive power

(vi) Propulsive efficiency

(vii) Overall efficiency

[20 marks]

Q.3 (a) (i) A shaft with diameter D = 80 mm and a length 400 mm, as shown in figure is pulled with a constant velocity of U = 5 m/s through a bearing with variable diameter. The clearance between shaft and bearing, which varies from h_1 = 1.2 mm to h_2 = 0.4 mm, is filled with a Newtonian lubricant whose dynamic viscosity is 0.10 Pa.s. The shaft is rotating with a constant angular speed of n = 1450 rpm in a bearing with variable diameter. The torque required to maintain the motion is



(ii) Define viscosity, state and explain Newton's law of viscosity. Derive the expression for shear stress in terms of velocity gradient. Support your explanation with a neat diagram.

[10 + 10 marks]

Q.3 (b) (i) Explain radial flow reaction turbine. Describe its main components with the help of schematic diagram.

(ii) A Francis turbine with an overall efficiency of 75% is required to produce 150 kW power. It is working under a head (H) of 7.5 m. The peripheral velocity = $0.25\sqrt{2gH}$ and the radial velocity of flow at inlet is $0.95\sqrt{2gH}$. The wheel runs at 160 rpm and hydraulic losses in the turbine are 20% of the available energy. Assuming radial discharge, determine:

(i) The guide blade angle

(ii) The wheel angle at inlet

(iii) Diameter of wheel at inlet, and

(iv) Width of the wheel at inlet

[10 + 10 marks]

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Q.3 (c) The ultimate analysis of a coal used in steam generator is as follows carbon 63.0%, hydrogen 1.8%, sulphur 0.9%, nitrogen 1.7%, oxygen 1.4%, moisture 4.5% and ash 26.7% HHV of coal is 26 MJ/kg.

Analysis of flue gas reveals the following points.

CO_2 = 12.5%, CO = 1.7%, O_2 = 8%, N_2 = 77.8%

It is assumed that there is no unburnt carbon after combustion. Exhaust gas temperature is measured as 180°C, Unaccounted energy loss = 2.5% of HHV, Steam generation rate = 175 T/h, Steam condition at boiler outlet is equivalent to 120 bar and 500°C. Feed water inlet temperature is kept at 150°C. Heat of reaction for CO and CO_2 are 33 MJ/kg carbon and 9.5 MJ/kg carbon. Consider specific heat for dry flue gas as 1.05 kJ/kgK and ambient temperature as 35°C. Calculate

(i) The amount of dry flue gas produced per kg of fuel.

(ii) The dry exhaust loss and incomplete combustion loss per kg of fuel.

(iii) Efficiency of boiler

(iv) Burning rate of the fuel

(v) The percentage of excess air used

[Use Steam Table attached at the end]

[20 marks]

Q.4 (a) Air is flowing over a flate plate 500 mm long and 500 mm wide with a velocity of 5 m/s. The kinematic viscosity of air is given by 0.1×10^{-4} m²/s. Find

(i) the boundary layer thickness at the end of the plate.

(ii) shear stress at the end of the plate.

The velocity profile over the plate as $\frac{U}{U_\infty} = \sin\left(\frac{\pi}{2}\frac{y}{\delta}\right)$ and density of air 1.2 kg/m³

[20 marks]

$U_\infty = 5 m/s$ $L = 0.5 m$ $b = 0.5 m$

$\nu = 0.1 \times 10^{-4} m^2/s$

$Re_L = \frac{U_\infty L}{\nu} = \frac{5 \times 0.5}{0.1 \times 10^{-4}} = 2.5 \times 10^5 < 5 \times 10^5$

flow Remains laminar over entire length of plate.

$\theta = \int_0^\delta \frac{U}{U_\infty}\left(1 - \frac{U}{U_\infty}\right) dy$ = Momentum Thickness

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$$\theta = \int_0^{\delta} \sin\left(\frac{\pi}{2}\cdot\frac{y}{\delta}\right)\left(1 - \sin\left(\frac{\pi}{2}\frac{y}{\delta}\right)\right) dy .$$

let $\eta = \frac{y}{\delta}$ $\delta\, d\eta = dy$

$$\theta = \delta \int_0^1 \sin\left(\frac{\pi}{2}\eta\right)\left(1 - \sin\left(\frac{\pi}{2}\eta\right)\right) d\eta .$$

$$\theta = \left(\frac{4-\pi}{2\pi}\right)\delta = 0.1366\,\delta .$$

Von karman momentum integral Equation.

$$\frac{\tau_0}{\rho U_\infty^2} = \frac{d\theta}{dx} .$$

$$\tau_0 = \mu \frac{du}{dy} = \mu\, U_\infty \left(\frac{\pi}{2\delta}\right) \cos\left(\frac{\pi}{2\delta} y\right)\Big|_{y=0}$$

$$\tau_0 = \frac{\mu U_\infty \pi}{2\delta}$$

$$\frac{\frac{\mu U_\infty \pi}{2\delta}}{\rho U_\infty^2} = \left(\frac{4-\pi}{2\pi}\right)\frac{d\delta}{dx} .$$

$$\frac{(\mu/\rho)}{2 U_\infty \delta}\left(\frac{2\pi^2}{4-\pi}\right) = \frac{d\delta}{dx}$$

$$\frac{(\mu/\rho)\, 2\pi^2}{2\, U_\infty\, (4-\pi)}\, dx = \delta\, d\delta$$

$$\frac{(\mu/\rho)\pi^2}{U_\infty (4-\pi)} x + C = \frac{\delta^2}{2}$$

$\left\{ \begin{array}{l} \text{at } x = 0 \\ \delta = 0 \end{array} \right\}$ $\Downarrow$ $C = 0$

$$\delta^2 = \frac{2\pi^2}{(4-\pi)} \frac{\nu x}{U_\infty}$$

$$\delta^2 = \left(\frac{2\pi^2}{4-\pi}\right) \frac{\nu x^2}{U_\infty x}$$

$$\delta = \sqrt{\frac{2\pi^2}{(4-\pi)}} \frac{x}{\sqrt{\frac{U_\infty x}{\nu}}}$$

$$\delta = \sqrt{\left(\frac{2\pi^2}{4-\pi}\right)} \frac{x}{\sqrt{Re_x}}$$

$$\delta = \frac{4.795\, x}{\sqrt{Re_x}}$$

$$\delta\big|_{x=L} = \frac{4.795 \times 0.5}{\sqrt{2.5\times10^5}} = 4.795\times10^{-3}\, m$$

$$\boxed{\delta\big|_{x=L} = 4.795\ mm}$$ (Ans)

$$\tau_0 = \frac{\mu U_\infty \pi}{2\delta}$$

$$\tau_0 = \frac{(0.1\times10^{-4}\times 1.2)\times 5\times\pi}{2\times4.795\times10^{-3}}$$

(20)

$$\boxed{\tau_0 = 0.01965\ Pa}$$ (Ans)

shear stress at the end of the plate.

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.4 (b) A 4800 kW gas turbine generating set operates with two compressor stages, the overall pressure ratio is 9 : 1. A high pressure turbine is used to drive the compressors, and a low pressure turbine drives the generator. The temperature of the gases at entry to the high pressure turbine is 650°C and the gases are reheated to 650° after expansion in the first turbine. The exhaust gases leaving the low pressure turbine are passed through a heat exchanger to heat air leaving the high pressure stage compressor. The compressors have equal pressure ratios and intercooling, is complete between the stages. The air inlet temperature to the unit is 25°C. The isentropic efficiency of each compressor stage is 0.82 and the isentropic efficiency of each turbine stage is 0.85, the heat exchanger thermal ratio is 0.8. A mechanical efficiency of 92% can be assumed for both the power shaft and compressor turbine shaft. Neglecting all pressure losses and changes in kinetic energy. Calculate

(i) The thermal efficiency.

(ii) Work ratio of the plant.

(iii) The mass flow in kg/s

Neglect the mass of the fuel and assume the following:

For air, $c_{pa} = 1.005$ kJ/kgK and $\gamma = 1.4$

For gases in the combustion chamber and in turbines and heat exchanger, $c_{pg} = 1.15$ kJ/kgK and $\gamma = 1.333$

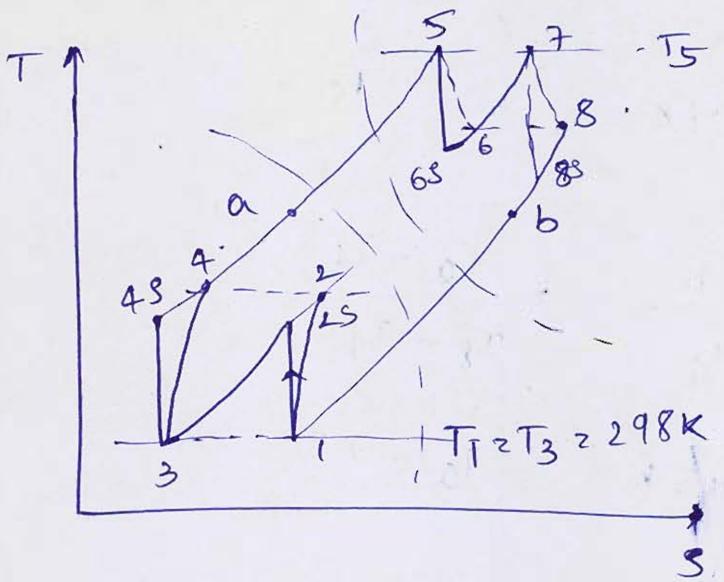
[20 marks]

$(r_p)_0 = 9:1$ $\quad T_1 = 298\text{ K}$.

$\eta_{comp} = 0.82$ $\quad \eta_{Turbine} = 0.85$.

$\epsilon = 0.8$. $\quad \eta_{mech} = 0.92$.

$T_5 = T_7 = 923\text{ K}$.



$P_i = \sqrt{P_L\, P_h}$

$= \sqrt{1 \times 9}$

$= 3$ bar.

$\dfrac{T_{2s}}{T_1} = (3)^{\frac{1.4-1}{1.4}}$

$T_{2s} = 407.88\text{ K}$ $\qquad \dfrac{T_{2s} - T_1}{T_2 - T_1} = 0.82 \Rightarrow T_2$.

$T_2 = 432K = T_4$

As HPT is used to drive compressors.

$$\frac{W_{C1} + W_{C2}}{\eta_{mech}} = C_{pg}(T_5 - T_6)$$

$$\frac{2C_{pa}(T_2 - T_1)}{\eta_{mech}} = C_{pg}(T_5 - T_6).$$

$$\frac{2 \times 1.005 (T_2 - T_1)}{\eta_{mech}} = 1.15(923 - T_6).$$

$T_6 =$ ~~692.28K~~ $668.42\ K$

$$\frac{T_5 - T_6}{T_5 - T_{6S}} = 0.85 \longrightarrow T_{6S} = \text{~~651.56K~~}\ 623.49K$$

$$\frac{T_5}{T_{6S}} = (r_p)_1^{\frac{\gamma-1}{\gamma}} \qquad \gamma = 1.333$$

$(r_p)_1 = 4.8$~~[illegible]~~1 (Pressure ratio in HPT).

$(r_p)_2 =$ ~~2.23~~ 1.87 (Pressure ratio in LPT).

$$\frac{923}{T_{8S}} = 1.87^{\frac{0.333}{1.33}} \qquad \eta_T = \frac{T_7 - T_8}{T_7 - T_{8S}} = 0.85.$$

$T_{8S} = 789.21K$ $\qquad T_8 = 809.28K.$

$$\epsilon = 0.8 = \frac{T_8 - T_b}{T_8 - T_4} = \frac{T_a - T_4}{T_8 - T_4}$$

$T_b = 507.45K \qquad T_a = 733.82K.$

$$\eta_{th} = \frac{W_{net}}{Q_{added}}$$

$$W_{net} = W_{HPT} + W_{LPT} - \frac{(W_{C1} + W_{C2})}{\eta_{meh}}.$$

$$= W_{LPT} = C_{pg}(T_7 - T_8).$$

$$W_{net} = 130.78 \frac{kJ}{kg}$$

$$Q_{added} = (Q_{a-5}) + (Q_{6-7}).$$

8

$$= [1.15(923) - 1.005(733.82)]$$

$$+ [1.15(923) - 1.15(668.42)].$$

$$= 616.78 \text{ kJ/kg}.$$

$$\boxed{\eta_{th} = 21.2\%}$$ → Thermal Efficiency. (i)

$$W.R = \frac{W_{net}}{W_T} = \frac{130.78}{130.78 + 1.15(923 - 668.42)}$$

$$\boxed{W.R = 30.87\%}$$ → (ii)

$$\dot{m}(130.78) = 4800$$

$$\boxed{\dot{m} = 36.7 \text{ kg/s}}$$ → (iii)

mass flow rate.

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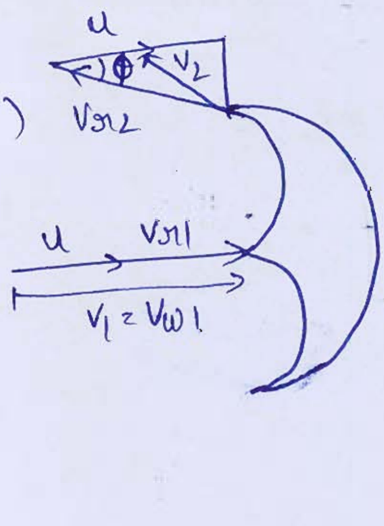
Q.4 (c) (i) A jet of water having a velocity of 30 m/s impinges on a series of vanes moving with a velocity of 14 m/s. The jet makes an angle of 25° to the direction of motion of vanes entering and leaves at an angle of 125°. Draw the velocity triangles at inlet and outlet and find

1. the angles of vanes tip so that water enters and leaves without shock.
2. the work done per unit weight of water entering and leaves without shock.
3. the efficiency

(ii) Derive the expression for the efficiency of a pelton turbine. Also determine the condition for maximum efficiency and obtain the expression for the maximum efficiency of turbine.

[10 + 10 marks]

(ii)



$$W \cdot D = (V_{w1} + V_{w2})\, u\, \dot{m}$$

$$\eta = \frac{u\,(V_{w1} + V_{w2})}{\left(\frac{V_1^2}{2}\right)}.$$

$V_{w1} = V_1 \qquad V_{r1} = (V_1 - u)$

$V_{w2} = V_{r2}\cos\phi - u.$

let $V_{r2} = k V_{r1}$

$V_{w2} = k V_{r1} \cos\phi - u$

$= k (V_1 - u) \cos\phi - u$

$$\eta = \frac{2u\left(V_1 + (k(V_1 - u)(\cos\phi) - u\right)}{V_1^2}$$

$$\eta = \frac{2u(V_1 - u)(1 + k\cos\phi)}{V_1^2}$$

$$\eta = 2\left(\frac{u}{V_1}\right)\left(1 - \frac{u}{V_1}\right)(1 + k\cos\phi)$$

let $\rho = \frac{u}{V_1}$

$$\eta = 2\rho(1-\rho)(1 + k\cos\phi)$$

$\frac{d\eta}{d\rho} = 0$ for η_{max}

$1 - 2\rho = 0 \implies \rho = 1/2$

$\boxed{u = \frac{V_1}{2}}$ → condition for maximum efficiency.

10

$\eta_{max} = 2(0.5)(0.5)(1 + k\cos\phi)$

$$\boxed{\eta_{max} = \frac{1 + k\cos\phi}{2}}$$

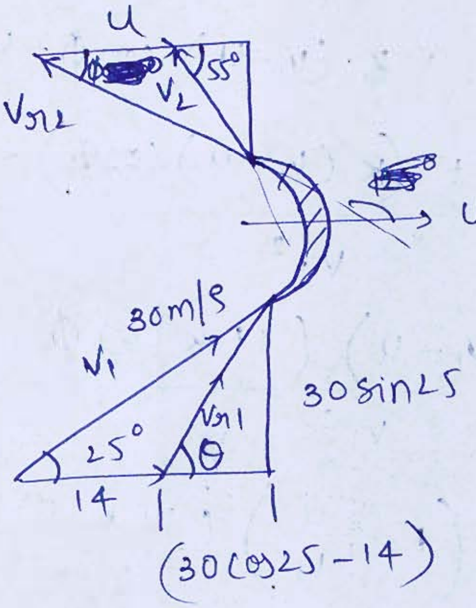
If blade is friction less $k = 1$

$$\boxed{\eta_{max} = \frac{1 + \cos\phi}{2}}$$

ϕ = Exit vane angle

(i) $V_1 = 30 m/s$

$u = 14 m/s$



$$\tan\theta = \frac{30\sin 25}{30\cos 25 - 14} \Rightarrow \boxed{\theta = 43.87°}$$

$V_{r1} = 18.29 m/s$

let blade is frictionless

$\Rightarrow V_{r1} = V_{r2} = 18.29$

$$\frac{u}{\sin(180 - 125 - \phi)} = \frac{V_{r2}}{\sin 125}$$

$$\boxed{\phi = 16.17°}$$

angles of vane tip $\Rightarrow$ $\theta = 43.87°$, $\phi = 16.17°$

(i) ←

$$\frac{W.D}{\dot{m}g} = \frac{(V_{w1} + V_{w2})u}{g}$$

$V_{w1} = 30\cos 25 = 27.19 \text{ m/s}$.

$V_{w2} = 18.29\cos(16.17) - 14 = 3.566 \text{ m/s}$

$u = 14 \text{ m/s}$

$g = 9.81$

$$\boxed{\frac{W.D}{\dot{m}g} = 43.89 \text{ m}} \rightarrow \text{(ii)}$$

$$\eta = \frac{(V_{w1} + V_{w2})u}{\left(\frac{V_1^2}{2}\right)} = 95.68\%$$

$$\boxed{\eta = 95.68\%} \rightarrow \text{(iii)}$$

10

Section B : Fluid Mechanics + Fluid Machinery + Power Plant

Q.5 (a) **(i)** The tangential component of velocity of incompressible fluid in 2-D flow is

$$v_\theta = -\frac{c\sin\theta}{r^2}$$

where c is a constant

1. Using continuity equation, determine the expression for radial velocity v_r.
2. Find the magnitude and direction of resultant velocity

(ii) If the velocity field is given by $u = (16y - 8x)$, $v = (8y - 7x)$, find the circulation around the closed curve defined by $x = 4, y = 2, x = 8, y = 8$.

[6 + 6 marks]

(i) continuity in polar form.

$$\frac{\partial V_r}{\partial r} + \frac{1}{r}\frac{\partial V_\theta}{\partial \theta} = 0$$

V_r = radial velocity.

$$\frac{\partial V_r}{\partial r} = -\frac{1}{r}\frac{\partial}{\partial\theta}\left(-\frac{c\sin\theta}{r^2}\right)$$

$$= -\frac{1}{r}\left(-\frac{c}{r^2}\right)\cos\theta$$

$$\frac{\partial V_r}{\partial r} = \frac{c}{r^3}\cos\theta$$

$$\partial V_r = c\, r^{-3}\cos\theta\, dr$$

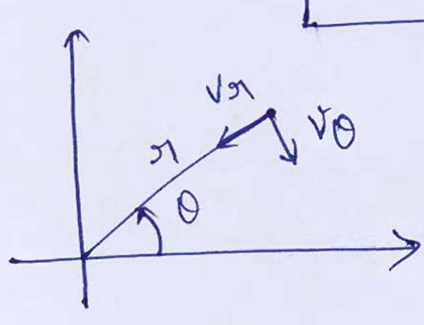
$$V_r = c\cos\theta\int r^{-3}\,dr$$

$$V_r = c\cos\theta\left(\frac{r^{-2}}{-2}\right) + c_1$$

$$\boxed{V_r = -\frac{c\cos\theta}{2r^2} + c_1}$$

c_1 = const of integration

(4)



$$V = \sqrt{V_\theta^2 + V_r^2}$$

V

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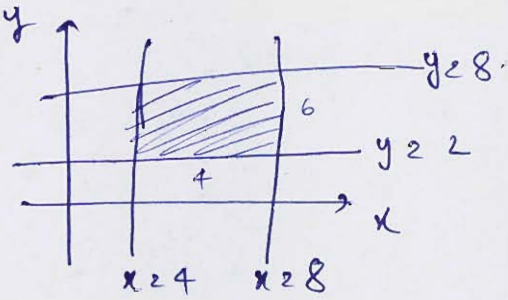
(ii) $u = (16y - 8x)$

$v = (8y - 7x)$



$\Gamma = \int u \cdot dL$

$= \Omega \times \text{Area} = \text{Vorticity} \times \text{Area enclosed}$

$\Omega_z = \left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right)$

$= -7 - 16$

$= -23.$

$\Gamma = (-23) \times (6 \times 4)$

$\boxed{\Gamma = -552 \text{ units}}$

(circulation)

(6)

.5 (b) An elbow type draft tube has a circular section of 1.8 m^2 at the top and a rectangular section of 13.5 m^2 at the exit section. The turbine is set at a height of 2 m above the tail race level. If the velocity at the inlet of the to the draft tube is 12.5 m/s. Determine

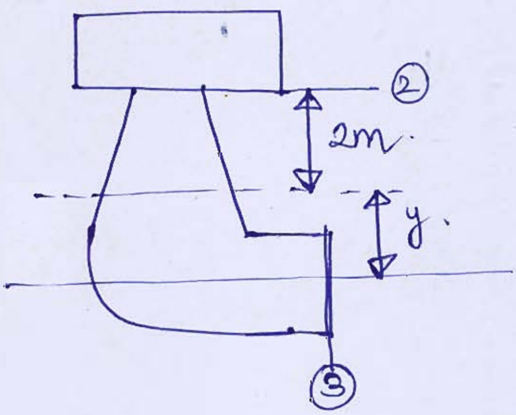
(i) Negative pressure head at the inlet to the draft tube.

(ii) Power thrown away into the tail race and

(iii) Efficiency of the draft tube

Assume the frictional losses in the draft tube to be 10% of the inlet velocity head.

[12 marks]



$A_2 = 1.8\,m^2$.

$A_3 = 13.5\,m^2$.

$V_2 = 12.5\,m/s$.

$A_2 V_2 = A_3 V_3$.

$\frac{1.8}{13.5} \times 12.5 = V_3$

$V_3 = 1.67\,m/s$.

$$\frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2 = \frac{P_3}{\rho g} + \frac{V_3^2}{2g} + 0 + h_L$$

$$h_L = 0.1\left(\frac{V_2^2}{2g}\right).$$

$$\frac{P_2}{\rho g} + \left(\frac{12.5^2}{2g}\right) + (2 + y) = \frac{P_{atm}}{\rho g} + y + \frac{1.67^2}{2g} + \left(\frac{0.1 \times 12.5^2}{2 \times g}\right)$$

$$\frac{P_2}{\rho g} = \frac{P_{atm}}{\rho g} + \left(\frac{1.67^2}{2g}\right) + \left(\frac{0.1 \times 12.5^2}{2g}\right) - \left(\frac{12.5^2}{2g}\right)$$

$$\frac{P_2}{\rho g} = \frac{P_{atm}}{\rho g} - \left(\frac{0.9(12.5^2)}{2g} - \frac{1.67^2}{2g}\right)$$

$$\frac{P_2}{\rho g} = \frac{P_{atm}}{\rho g} - (7.025\ m)$$

(i) Negative pressure ~~at~~ inlet to draft tube = $-7.025m$

(ii) power thrown away in to tail Race = $\frac{V_3^2}{2}\ \frac{J}{kg}$

$= 1.3945 \frac{J}{kg}$

(iii) $$\eta = \frac{\frac{V_2^2}{2} - \frac{V_3^2}{2} - h_L}{\frac{V_2^2}{2}}$$

$\eta = 88.2\%$

7

Q.5 (c) Briefly explain the following:

1. Turbojet engine
2. Turbofan engine
3. Turboprop engine
4. Ramjet engine
5. Scramjet engine
6. Pulse jet engine

[12 marks]

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Q.5 (d) With the help of a neat schematic explain the working of a circulating type fluidized bed boilers.

[12 marks]

5 (e) A surface condenser deals with 14000 kg of steam per hour. The leakage air in the system amounts to 2 kg per 2800 kg of steam. The vacuum in the air pump suction is 710 mm of mercury (barometer reads 760 mm of Hg) and temperature is 35°C.

Determine the discharging capacity of the wet air pump which remove both air and condensate in m^3 per minute, taking the volumetric efficiency of the pump as 92%.

If the air pump is single acting and runs at 80 rpm and piston stroke is 1.25 times the diameter of the pump, find the dimensions of the wet air pump.

[Use Steam Table attached at the end]

[12 marks]

Q.6 (a) Following data relate to a performance test of a single acting 15 cm × 10 cm reciprocating compressor:

Suction pressure = 1 bar; Suction temperature = 25°C

Discharge pressure = 8 bar; Discharge temperature = 200°C

Speed of compressor = 1250 rpm; Shaft power = 8.25 kW

Mass of air delivered = 2 kg/min

Calculate the following:

(i) The actual volumetric efficiency.

(ii) The indicated power.

(iii) The isothermal efficiency.

(iv) The mechanical efficiency.

(iii) The overall isothermal efficiency

[20 marks]

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6 (b) The diameter of the runner of a vertical-shaft turbine is 450 mm at the inlet. The width of the runner at the inlet is 50 mm. The diameter and width at the outlet are 300 mm and 75 mm, respectively. The blades occupy 8% of the circumference. The guide vane angle is 24°, the inlet angle of the runner blade is 95° and the outlet angle is 30°. The fluid leaves the runner without any whirl. The pressure head at the inlet is 55 mm above that at the exit from the runner. The fluid friction losses account for 18% of the pressure head at inlet. Calculate the speed of the runner and the output power (use mechanical efficiency as 95%)

[20 marks]

$D_1 = 450$ mm $\quad D_2 = 300$ mm

$B_1 = 50$ mm $\quad B_2 = 75$ mm

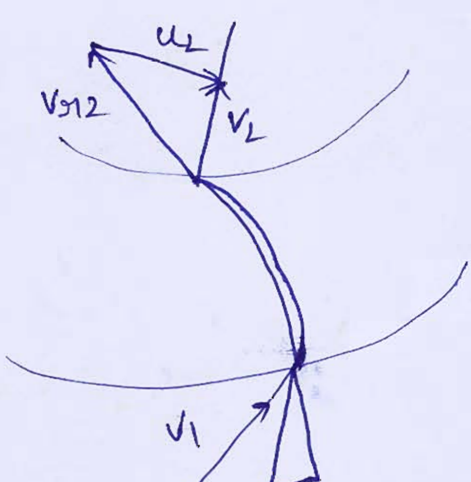
$K_1 = 0.92$ (Blade area coefficient)

$\alpha = 24^0$

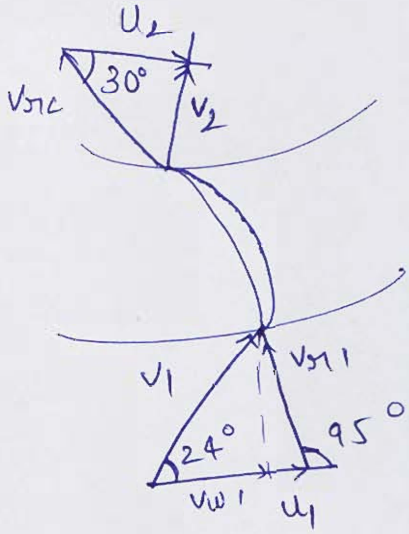
$\theta = 95^0$

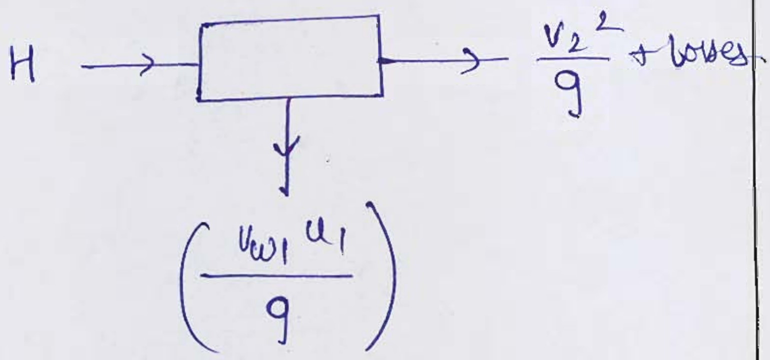
$\phi = 30^0$.

$V_{f2} = 0$

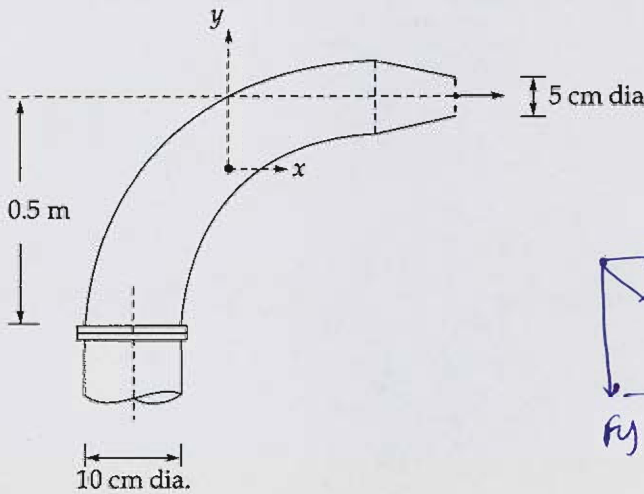


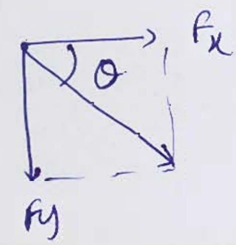
0 (00)


u_2
30°
V_{r2}
V_2
V_1
V_{r1}
24°
95°
V_{w1}
u_1


H
$\frac{V_2^2}{g}$ + losses
$\left(\frac{V_{w1} u_1}{g}\right)$

Q.6 (c) Water flows into atmosphere through a vertical bend nozzle assembly shown in figure below. The pipe diameter is 10 cm and the nozzle exit diameter is 5 cm. The rate of flow of water is 2400 litre per minute. The interior volume of the assembly is 18.2 litre. The head loss in the bend is $0.5\, v^2/2g$ and in the nozzle it is v^2/g, where v is the velocity of water in the pipe. Determine the hydrodynamic force on the system and its direction.

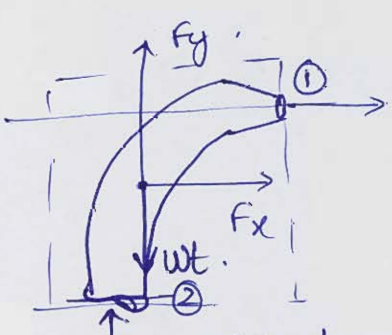




[20 marks]

$$Q = 2400 \frac{\text{lit}}{\text{min}} = 0.04 \frac{m^3}{s}$$

$$v = \frac{0.04}{\frac{\pi}{4}(0.1)^2} = 5.093 \text{ m/s}$$



$V_1 = 20.37$ m/s

↑ 5.093 m/s.

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2 + h_L$$

$$\frac{P_{atm}}{\rho g} + \left(\frac{20.37^2}{2\times 9.81}\right) + 0.5 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + 0 + h_L$$

$$\cancel{\frac{P_{atm}}{\rho g}}^{0} + \left(\frac{20.37^2}{2\times 9.81}\right) + 0.5 = \frac{P_2}{\rho g} + \frac{5.093^2}{2g} + \frac{1.5(5.09^2)}{2g}$$

$$\cancel{\left(\frac{P_{atm}}{\rho g}\right)}^{0} + 18.3473 = \frac{P_2}{\rho g}$$

$P_2 = 101.325 kPa + 179.987$

$P_2 = ~~281.31 kPa~~ \; 179.987 \; kPa$

$\Sigma F_x = \dot{m}(V-u)_x$

$F_x - (P_{atm} A_1) = \rho Q (20.37 - 0)$

$F_x = \left[~~101.325 kPa \times \frac{\pi}{4}(0.05)^2~~\right]$

$+ \left[1000 \times 0.04 \times (20.37)\right]$

$\boxed{F_x = 814.8 N}$

8

$\Sigma F_y = \dot{m}(V-u)_y$

$\begin{bmatrix} F_y - (Wt) \\ + P_2 A_2 \end{bmatrix} = 1000 \times 0.04 (0 - 5.093)$

$F_y = Wt - 1000 \times 0.04 (5.093) - P_2 A_2$

$Wt = 1000 \times 9.81 \times 18.2 \times 10^{-3}$

$Wt = 178.54 N$

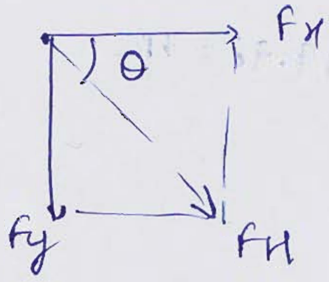
~~$F_y = -25.18 N$~~

$\boxed{F_y = -1438.79 N}$

$F_{Hydrodynamic} = ~~815.18898~~ \sqrt{F_x^2 + F_y^2}$

$= \sqrt{814.8^2 + 1438.79^2}$

$= 1653.49 N$



$\theta = 60.48^\circ$

$F_H = 1653.59\ N$

Q.7 (a) (i) A pipeline carrying water has surface protrusions of average height of 0.12 mm. If the shear stress developed is 8.6 Pa, determine whether the pipe surface acts as smooth, rough or in transition. For water take $\rho = 1000\ kg/m^3$ and kinematic viscosity $\nu = 0.0093$ stokes.

(ii) The velocity of flow in a badly corroded 8 cm pipe is found to increase 20 percent as a Pitot tube is moved from a point 1 cm from the wall to a point 2 cm from the wall. Estimate the height of roughness elements.

[10 + 10 marks]

(i) $K = 0.12mm$

$V^* = \sqrt{\frac{\tau_0}{\rho}}$ = shear Velocity.

$= \sqrt{\frac{8.6}{1000}}$

$V^* = 0.093$.

$\delta' =$ laminar sublayer.

$\delta' = \frac{11.6\ \nu}{V^*}$

$\delta' = \frac{11.6 \times 0.0093 \times 10^{-4}}{(0.0927)}$

$\delta' = 1.1633 \times 10^{-4} m$

$\delta' = 0.1163 mm$.

Acc. to Nikuradse

if $\frac{k}{\delta'} < 0.25$ Hydrodynamically smooth

$0.25 < \frac{k}{\delta'} < 6$ transition.

$\frac{k}{\delta'} > 6$. Rough.

Here in this case

$\frac{k}{\delta'} = \frac{0.12}{0.1163} = 1.03 \in [0.25, 6]$

$\therefore$ The pipe surface is in transition.

10

(ii) $D = 8\,cm$

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Q.7 (b) (i) Explain the working principle of a wet type cooling tower. Also, classify and describe the various types of wet cooling towers with neat sketches.

(ii) Water at 35°C flows into a cooling tower at the rate of 1.2 kg per kg air. Air enters the tower at *dbt* of 25°C and relative humidity of 50% and leaves it at *dbt* of 30°C and 80% relative humidity. Makeup water is supplied at 25°C. Determine

(i) The temperature of water leaving the tower.

(ii) The fraction of water evaporated and

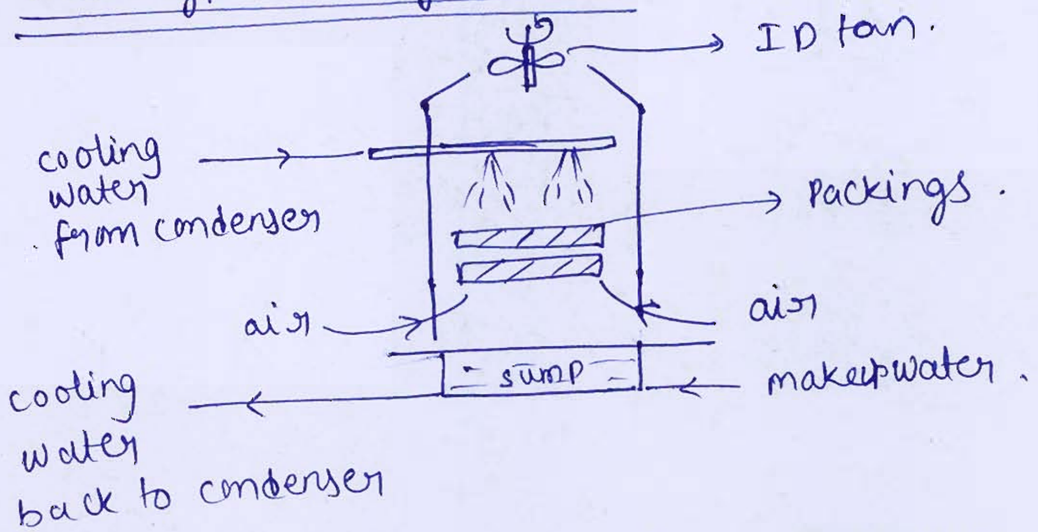
(iii) The approach and range of cooling tower

[Take atmospheric pressure, $P = 1$ bar & specific heat of water as 4.18 kJ/kgK]

[Use Steam Table and Psychrometric chart attached at the end]

[10 + 10 marks]

(i) Wet Type cooling Tower

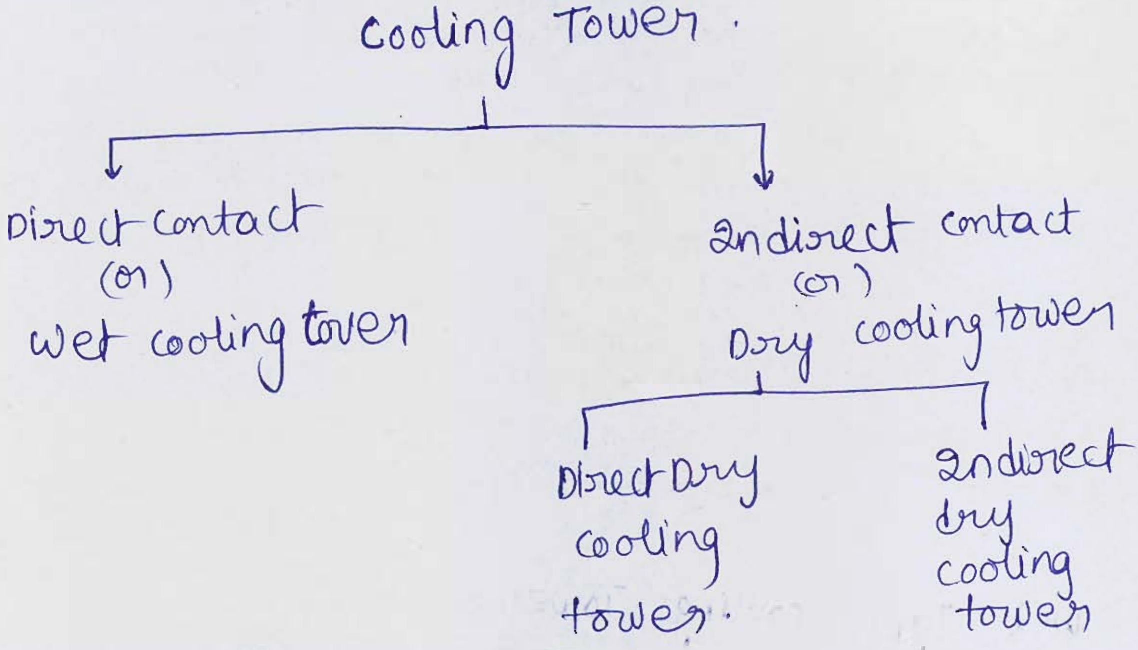


6

The warm cooling water from condenser is sprayed inside cooling tower so that is comes in direct contact with air.

Packings and baffles are used to maximise the surface area.

some water get evaporated there water and humidifying by cooling the the air.


Cooling Tower.
Direct contact
(or)
wet cooling tower
Indirect contact
(or)
Dry cooling tower.
Direct Dry
cooling
tower.
Indirect
dry
cooling
tower

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Q.7 (c) The following data relate to a Kaplan turbine:

Shaft power = 22500 kW; Head = 20 m; Speed = 148 rpm;

Hydraulic efficiency = 95%; Overall efficiency = 89%; Diameter of the runner = 4.5 m

Diameter of the hub = 2 m; Runner vane angle at outlet = 34°

Assuming that the velocity of flow is constant. Find:

(i) Guide vane angle at inlet;

(ii) Runner vane angle at inlet

[20 marks]

$\eta_H = 0.95 = \frac{R.P}{W.P}$ $\eta_0 = \frac{SP}{WP} = 0.89.$

$D_r = 4.5m$ $D_h = 2m$ $D_m = \frac{4.5+2}{2} = 3.25m$

$WP = \frac{22500}{0.89} = 25280.9\,kW = \cancel{1000}\,Q(9.81)20$

$Q = 128.85\,\frac{m^3}{s}$

$RP = 24016.85\,kW$

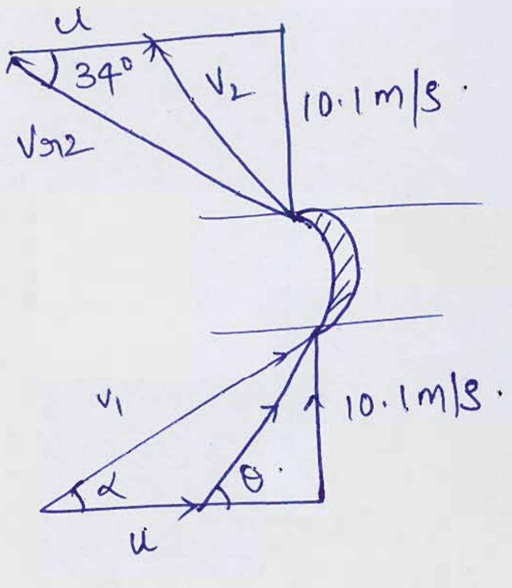
$V_f \frac{\pi}{4}(4.5^2 - 2^2) = 128.85.$

$V_f = 10.1\,m/s.$

at D_m

$U = \frac{\pi D_m N}{60}$

$U = 25.185\,m/s$



$24016.85\,kW = \cancel{\rho} Q(V_{w1} + V_{w2})\,u$

$\frac{24016.85}{128.85} = (V_{w1} + V_{w2})\,25.185$

$V_{w1} + V_{w2} = 7.40\,m/s \longrightarrow (1)$

$V_{r2} \sin 34^\circ = 10.1\,m/s$

$V_{r2} = 18.06\,m/s.$

$V_{w2} = (V_{r2} \cos 34) - u$

$$\boxed{V_{w2} = -10.21 \text{ m/s}}$$

$V_{w1} + V_{w2} = 7.40$

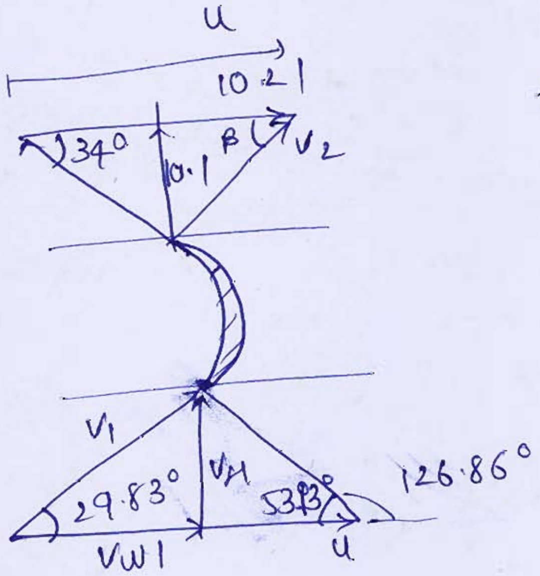
$$\boxed{V_{w1} = 17.61 \text{ m/s}}$$

$\tan \alpha = \frac{10.1}{17.61}$

$$\boxed{\alpha = 29.8343^\circ}$$ → Guide vane angle at inlet.

$\tan \theta = \frac{10.1}{17.61 - 25.185}$

$$\boxed{\theta = -53.13^\circ \Rightarrow 126.86^\circ}$$ ⇒ Runner vane angle at inlet



$\tan \beta = \frac{10.1}{10.21}$

$$\boxed{\beta = 44.68^\circ}$$

↳ guide vane angle at inlet.

Q.8 (a) **(i)** A boiler uses 2100 kg/h of coal. The temperatures of air supplied is 290 K and the average temperature of the flue gas leaving the chimney is 620 K. The 35 m high chimney produces a drought of 22 mm of water column. Determine

1. Quantity of air supplied per kg of coal.
2. The draught in terms of column of hot gases, and
3. The base diameter of chimney.

Assume that 10% of the theoretical draught is used for creating the flow velocity of gases through the chimney.

(ii) The following readings were obtained during a boiler trial of 6 hours duration:

Mean steam pressure = 12 bar; Mass of steam generated = 45000 kg; Mean dryness fraction = 0.9; Mean feed water temperature = 30°C; Cool used 5000 kg; Calorific value of coal = 33500 kJ/kg.

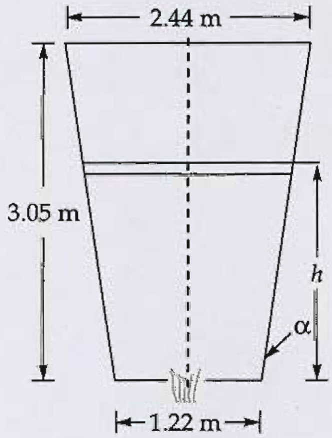
Calculate:

1. Factor of equivalent evaporation.
2. Equivalent evaporation from and at 100°C.
3. Efficiency of the boiler.

[Use Steam Table attached at the end]

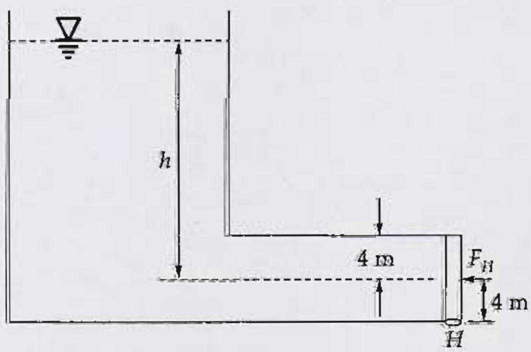
[10 + 10 marks]

(b) (i) A tank has the form of a frustum of a cone, with a diameter of 2.44 m at the top and 1.22 m at the bottom is shown in figure. The bottom contains a circular orifice whose coefficient of discharge is 0.60. What diameter of the orifice will empty the tank in 6 minutes if the full depth is 3.05 m?



A tank in the form of a frustum of a cone

(ii) A 3 m wide, 8 m high rectangular gate is located at the end of a rectangular passage that is connected to a large open tank filled with water as shown in figure. The gate is hinged at its bottom and held closed by a horizontal force, F_H located at the centre of the gate. The maximum value for F_H is 3500 kN.



1. Determine the maximum water depth above the centre of the gate that can exist without the gate opening.
2. Will the answer be same, if the gate is hinged at the top? Explain your answer.

[10 + 10 marks]

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(c) Air at 1.01325 bar and 300 K enters an axial flow compressor stage with an axial velocity 160 m/s. There are no inlet guide vanes. The rotor stage has a tip diameter of 65 cm and a hub diameter of 55 cm and rotates at 100 rps. The air enters the rotor and leaves the stator in the axial direction with no change in velocity or radius. The air is turned through 28° as it passes through rotor. Assume a stage pressure ratio of 1.25. Assuming the constant specific heats and that the air enters and leaves the blade at the blade angles.

(i) construct the velocity diagram at mean diameter for this stage,

(ii) mass flow rate,

(iii) power required, and

(iv) degree of reaction

[20 marks]

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Saturated Water and Steam (Temperature-based)

T	p_{sat}	Volume, m^3/kg		Energy, kJ/kg		Enthalpy, kJ/kg			Entropy, kJ/(kg K)		
°C	MPa	v_f	v_g	u_f	u_g	h_f	h_g	h_{fg}	s_f	s_g	s_{fg}
0.01	0.0006117	0.00100021	205.991	0	2374.9	0.00	2500.9	2500.9	0	9.1555	9.1555
1	0.0006571	0.00100015	192.439	4.18	2376.2	4.18	2502.7	2498.6	0.01526	9.1291	9.1138
2	0.0007060	0.00100011	179.758	8.39	2377.7	8.39	2504.6	2496.2	0.03061	9.1027	9.0720
3	0.0007581	0.00100008	168.008	12.60	2379.0	12.60	2506.4	2493.8	0.04589	9.0765	9.0306
4	0.0008135	0.00100007	157.116	16.81	2380.4	16.81	2508.2	2491.4	0.06110	9.0505	8.9894
5	0.0008726	0.00100008	147.011	21.02	2381.8	21.02	2510.1	2489.0	0.07625	9.0248	8.9486
6	0.0009354	0.00100011	137.633	25.22	2383.2	25.22	2511.9	2486.7	0.09134	8.9993	8.9080
7	0.0010021	0.00100014	128.923	29.43	2384.5	29.43	2513.7	2484.3	0.10637	8.9741	8.8677
8	0.0010730	0.00100020	120.829	33.63	2386.0	33.63	2515.6	2481.9	0.12133	8.9491	8.8278
9	0.0011483	0.00100026	113.304	37.82	2387.3	37.82	2517.4	2479.6	0.13624	8.9243	8.7881
10	0.0012282	0.00100035	106.303	42.02	2388.6	42.02	2519.2	2477.2	0.15109	8.8998	8.7487
11	0.0013130	0.00100044	99.787	46.22	2390.0	46.22	2521.0	2474.8	0.16587	8.8754	8.7096
12	0.0014028	0.00100055	93.719	50.41	2391.4	50.41	2522.9	2472.5	0.18061	8.8513	8.6707
13	0.0014981	0.00100067	88.064	54.60	2392.8	54.60	2524.7	2470.1	0.19528	8.8274	8.6321
14	0.0015990	0.00100080	82.793	58.79	2394.1	58.79	2526.5	2467.7	0.20990	8.8037	8.5938
15	0.0017058	0.00100094	77.875	62.98	2395.5	62.98	2528.3	2465.4	0.22446	8.7803	8.5558
16	0.0018188	0.00100110	73.286	67.17	2396.9	67.17	2530.2	2463.0	0.23897	8.7570	8.5180
17	0.0019384	0.00100127	69.001	71.36	2398.2	71.36	2532.0	2460.6	0.25343	8.7339	8.4805
18	0.0020647	0.00100145	64.998	75.54	2399.6	75.54	2533.8	2458.3	0.26783	8.7111	8.4433
19	0.0021983	0.00100164	61.256	79.73	2400.9	79.73	2535.6	2455.9	0.28218	8.6884	8.4063
20	0.0023393	0.00100184	57.757	83.91	2402.3	83.91	2537.4	2453.5	0.29648	8.6660	8.3695
21	0.0024882	0.00100205	54.483	88.10	2403.7	88.10	2539.3	2451.2	0.31073	8.6437	8.3330
22	0.0026453	0.00100228	51.418	92.28	2405.1	92.28	2541.1	2448.8	0.32493	8.6217	8.2967
23	0.0028111	0.00100251	48.548	96.46	2406.4	96.46	2542.9	2446.4	0.33908	8.5998	8.2607
24	0.0029858	0.00100275	45.858	100.65	2407.8	100.65	2544.7	2444.0	0.35318	8.5781	8.2250
25	0.0031699	0.00100301	43.337	104.83	2409.1	104.83	2546.5	2441.7	0.36722	8.5566	8.1894
26	0.0033639	0.00100327	40.973	109.01	2410.5	109.01	2548.3	2439.3	0.38123	8.5353	8.1541
27	0.0035681	0.00100354	38.754	113.19	2411.8	113.19	2550.1	2436.9	0.39518	8.5142	8.1191
28	0.0037831	0.00100382	36.672	117.37	2413.2	117.37	2551.9	2434.6	0.40908	8.4933	8.0842
29	0.0040092	0.00100411	34.716	121.55	2414.5	121.55	2553.7	2432.2	0.42294	8.4725	8.0496
30	0.0042470	0.00100441	32.878	125.73	2415.9	125.73	2555.5	2429.8	0.43675	8.4520	8.0152
31	0.0044969	0.00100472	31.151	129.91	2417.2	129.91	2557.3	2427.4	0.45052	8.4316	7.9810
32	0.0047596	0.00100504	29.526	134.09	2418.7	134.09	2559.2	2425.1	0.46424	8.4113	7.9471
33	0.0050354	0.00100537	27.998	138.26	2420.0	138.27	2561.0	2422.7	0.47792	8.3913	7.9134
34	0.0053251	0.00100570	26.560	142.44	2421.4	142.45	2562.8	2420.3	0.49155	8.3714	7.8799
35	0.0056290	0.00100605	25.205	146.62	2422.6	146.63	2564.5	2417.9	0.50513	8.3517	7.846
36	0.0059479	0.00100640	23.929	150.80	2424.0	150.81	2566.3	2415.5	0.51867	8.3321	7.813
37	0.0062823	0.00100676	22.727	154.98	2425.3	154.99	2568.1	2413.1	0.53217	8.3127	7.780
38	0.0066328	0.00100713	21.593	159.16	2426.7	159.17	2569.9	2410.8	0.54562	8.2935	7.747
39	0.0070002	0.00100750	20.524	163.34	2428.0	163.35	2571.7	2408.4	0.55903	8.2745	7.715
40	0.0073849	0.00100789	19.515	167.52	2429.4	167.53	2573.5	2406.0	0.57240	8.2555	7.683

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T	p_{sat}	Volume, m^3/kg		Energy, kJ/kg		Enthalpy, kJ/kg			Entropy, kJ/(kg K)		
°C	MPa	v_f	v_g	u_f	u_g	h_f	h_g	h_{fg}	s_f	s_g	s_{fg}
40	0.0073849	0.00100789	19.515	167.52	2429.4	167.53	2573.5	2406.0	0.57240	8.2555	7.6831
41	0.0077878	0.00100828	18.563	171.70	2430.7	171.71	2575.3	2403.6	0.58573	8.2368	7.6511
42	0.0082096	0.00100868	17.664	175.88	2432.1	175.89	2577.1	2401.2	0.59901	8.2182	7.6192
43	0.0086508	0.00100909	16.814	180.06	2433.4	180.07	2578.9	2398.8	0.61225	8.1998	7.5875
44	0.0091124	0.00100950	16.011	184.24	2434.7	184.25	2580.6	2396.4	0.62545	8.1815	7.5560
45	0.0095950	0.00100992	15.252	188.42	2436.1	188.43	2582.4	2394.0	0.63861	8.1633	7.5247
46	0.010099	0.00101036	14.534	192.61	2437.4	192.62	2584.2	2391.6	0.65173	8.1453	7.4936
47	0.010627	0.00101079	13.855	196.79	2438.8	196.80	2586.0	2389.2	0.66481	8.1275	7.4627
48	0.011177	0.00101124	13.212	200.97	2440.1	200.98	2587.8	2386.8	0.67785	8.1098	7.4320
49	0.011752	0.00101169	12.603	205.15	2441.4	205.16	2589.5	2384.4	0.69085	8.0922	7.4014
50	0.012352	0.00101215	12.027	209.33	2442.7	209.34	2591.3	2381.9	0.70381	8.0748	7.3710
51	0.012978	0.00101262	11.481	213.51	2444.1	213.52	2593.1	2379.5	0.71673	8.0576	7.3408
52	0.013631	0.00101309	10.963	217.70	2445.4	217.71	2594.8	2377.1	0.72961	8.0404	7.3108
53	0.014312	0.00101357	10.472	221.88	2446.7	221.89	2596.6	2374.7	0.74245	8.0234	7.2810
54	0.015022	0.00101406	10.006	226.05	2448.0	226.07	2598.3	2372.3	0.75526	8.0066	7.2513
55	0.015762	0.00101455	9.5643	230.24	2449.3	230.26	2600.1	2369.8	0.76802	7.9898	7.2218
56	0.016533	0.00101505	9.1448	234.42	2450.6	234.44	2601.8	2367.4	0.78075	7.9732	7.1925
57	0.017336	0.00101556	8.7466	238.60	2452.0	238.62	2603.6	2365.0	0.79344	7.9568	7.1633
58	0.018171	0.00101608	8.3683	242.79	2453.2	242.81	2605.3	2362.5	0.80610	7.9404	7.1343
59	0.019041	0.00101660	8.0089	246.97	2454.6	246.99	2607.1	2360.1	0.81871	7.9242	7.1055
60	0.019946	0.00101713	7.6672	251.16	2455.9	251.18	2608.8	2357.7	0.83129	7.9081	7.0769
61	0.020888	0.00101766	7.3424	255.35	2457.2	255.37	2610.6	2355.2	0.84384	7.8922	7.0484
62	0.021867	0.00101821	7.0335	259.53	2458.5	259.55	2612.3	2352.8	0.85634	7.8764	7.0200
63	0.022885	0.00101875	6.7396	263.72	2459.8	263.74	2614.0	2350.3	0.86882	7.8607	6.9918
64	0.023943	0.00101931	6.4598	267.91	2461.1	267.93	2615.8	2347.8	0.88125	7.8451	6.9638
65	0.025042	0.00101987	6.1935	272.09	2462.4	272.12	2617.5	2345.4	0.89365	7.8296	6.9359
66	0.026183	0.00102044	5.9399	276.27	2463.7	276.30	2619.2	2342.9	0.90602	7.8142	6.9082
67	0.027368	0.00102101	5.6984	280.46	2465.0	280.49	2621.0	2340.5	0.91835	7.7990	6.8807
68	0.028599	0.00102159	5.4682	284.65	2466.3	284.68	2622.7	2338.0	0.93064	7.7839	6.8532
69	0.029876	0.00102218	5.2488	288.84	2467.6	288.87	2624.4	2335.5	0.94291	7.7689	6.8260
70	0.031201	0.00102277	5.0395	293.04	2468.9	293.07	2626.1	2333.0	0.95513	7.7540	6.7989
71	0.032575	0.00102337	4.8400	297.23	2470.1	297.26	2627.8	2330.5	0.96733	7.7392	6.7719
72	0.034000	0.00102398	4.6496	301.42	2471.4	301.45	2629.5	2328.1	0.97949	7.7246	6.7451
73	0.035478	0.00102459	4.4680	305.60	2472.7	305.64	2631.2	2325.6	0.99161	7.7100	6.7184
74	0.037009	0.00102521	4.2945	309.80	2474.0	309.84	2632.9	2323.1	1.0037	7.6955	6.6918
75	0.038595	0.00102584	4.1289	313.99	2475.2	314.03	2634.6	2320.6	1.0158	7.6812	6.6654
76	0.040239	0.00102647	3.9708	318.18	2476.5	318.22	2636.3	2318.1	1.0278	7.6670	6.6392
77	0.041941	0.00102710	3.8197	322.38	2477.8	322.42	2638.0	2315.6	1.0398	7.6528	6.6130
78	0.043703	0.00102775	3.6752	326.58	2479.1	326.62	2639.7	2313.0	1.0517	7.6388	6.5871
79	0.045527	0.00102840	3.5372	330.76	2480.3	330.81	2641.3	2310.5	1.0637	7.6249	6.5612
80	0.047414	0.00102905	3.4052	334.96	2481.5	335.01	2643.0	2308.0	1.0756	7.6111	6.5355

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T	p_{sat}	Volume, m^3/kg		Energy, kJ/kg		Enthalpy, kJ/kg			Entropy, kJ/(kg K)		
°C	MPa	v_f	v_g	u_f	u_g	h_f	h_g	h_{fg}	s_f	s_g	s_{fg}
120	0.19867	0.00106033	0.89121	503.60	2528.8	503.81	2705.9	2202.1	1.5279	7.1291	5.6012
121	0.20505	0.00106123	0.86525	507.84	2530.0	508.06	2707.4	2199.3	1.5387	7.1186	5.5799
122	0.21159	0.00106215	0.84019	512.09	2531.0	512.31	2708.8	2196.5	1.5494	7.1081	5.5587
123	0.21830	0.00106307	0.81598	516.33	2532.2	516.56	2710.3	2193.7	1.5602	7.0977	5.5375
124	0.22518	0.00106400	0.79261	520.58	2533.2	520.82	2711.7	2190.9	1.5709	7.0873	5.5165
125	0.23224	0.00106494	0.77003	524.82	2534.3	525.07	2713.1	2188.0	1.5816	7.0770	5.4955
126	0.23947	0.00106588	0.74821	529.07	2535.3	529.33	2714.5	2185.2	1.5922	7.0668	5.4746
127	0.24689	0.00106683	0.72713	533.33	2536.4	533.59	2715.9	2182.3	1.6029	7.0566	5.4538
128	0.25450	0.00106778	0.70675	537.58	2537.4	537.85	2717.3	2179.5	1.6135	7.0465	5.4330
129	0.26229	0.00106874	0.68705	541.84	2538.5	542.12	2718.7	2176.6	1.6241	7.0364	5.4124
130	0.27028	0.00106971	0.66800	546.09	2539.6	546.38	2720.1	2173.7	1.6346	7.0264	5.3918
131	0.27846	0.00107068	0.64959	550.35	2540.6	550.65	2721.5	2170.8	1.6452	7.0165	5.3713
132	0.28685	0.00107166	0.63177	554.61	2541.6	554.92	2722.8	2167.9	1.6557	7.0066	5.3509
133	0.29543	0.00107265	0.61454	558.87	2542.6	559.19	2724.2	2165.0	1.6662	6.9967	5.3305
134	0.30423	0.00107365	0.59786	563.14	2543.6	563.47	2725.5	2162.1	1.6767	6.9869	5.3102
135	0.31323	0.00107465	0.58173	567.40	2544.7	567.74	2726.9	2159.1	1.6872	6.9772	5.2900
136	0.32245	0.00107566	0.56611	571.67	2545.7	572.02	2728.2	2156.2	1.6976	6.9675	5.2699
137	0.33188	0.00107667	0.55099	575.94	2546.6	576.30	2729.5	2153.2	1.7081	6.9579	5.2498
138	0.34154	0.00107769	0.53636	580.22	2547.6	580.59	2730.8	2150.3	1.7185	6.9483	5.2298
139	0.35143	0.00107872	0.52218	584.49	2548.6	584.87	2732.1	2147.3	1.7289	6.9388	5.2099
140	0.36154	0.00107976	0.50845	588.77	2549.6	589.16	2733.4	2144.3	1.7392	6.9293	5.1901
141	0.37189	0.00108080	0.49516	593.05	2550.6	593.45	2734.7	2141.3	1.7496	6.9199	5.1703
142	0.38247	0.00108185	0.48227	597.33	2551.5	597.74	2736.0	2138.3	1.7599	6.9105	5.1506
143	0.39329	0.00108291	0.46979	601.61	2552.5	602.04	2737.3	2135.2	1.7702	6.9011	5.1309
144	0.40437	0.00108397	0.45769	605.90	2553.4	606.34	2738.5	2132.2	1.7805	6.8919	5.1114
145	0.41568	0.00108504	0.44596	610.19	2554.4	610.64	2739.8	2129.2	1.7907	6.8826	5.0919
146	0.42726	0.00108612	0.43459	614.48	2555.3	614.94	2741.0	2126.1	1.8010	6.8734	5.0724
147	0.43909	0.00108720	0.42357	618.77	2556.3	619.25	2742.3	2123.0	1.8112	6.8643	5.0530
148	0.45118	0.00108830	0.41288	623.07	2557.2	623.56	2743.5	2119.9	1.8214	6.8552	5.0337
149	0.46354	0.00108940	0.40251	627.37	2558.1	627.87	2744.7	2116.9	1.8316	6.8461	5.0145
150	0.47616	0.00109050	0.39245	631.66	2559.0	632.18	2745.9	2113.7	1.8418	6.8371	4.9953
151	0.48907	0.00109162	0.38269	635.97	2559.9	636.50	2747.1	2110.6	1.8520	6.8281	4.9761
152	0.50225	0.00109274	0.37323	640.26	2560.8	640.81	2748.3	2107.5	1.8621	6.8192	4.9571
153	0.51571	0.00109387	0.36404	644.58	2561.8	645.14	2749.5	2104.3	1.8722	6.8103	4.9380
154	0.52946	0.00109501	0.35512	648.88	2562.7	649.46	2750.7	2101.2	1.8823	6.8014	4.9191
155	0.54350	0.00109615	0.34646	653.19	2563.5	653.79	2751.8	2098.0	1.8924	6.7926	4.9002
156	0.55784	0.00109730	0.33805	657.51	2564.4	658.12	2753.0	2094.8	1.9025	6.7838	4.8814
157	0.57247	0.00109846	0.32989	661.82	2565.2	662.45	2754.1	2091.6	1.9125	6.7751	4.8626
158	0.58742	0.00109963	0.32196	666.14	2566.1	666.79	2755.2	2088.4	1.9225	6.7664	4.8439
159	0.60267	0.00110081	0.31426	670.47	2566.9	671.13	2756.3	2085.2	1.9326	6.7578	4.8252
160	0.61823	0.00110199	0.30678	674.79	2567.7	675.47	2757.4	2082.0	1.9426	6.7491	4.8066

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p MPa	T_{sat} °C	Volume, m^3/kg v_f	v_g	Energy, kJ/kg u_f	u_g	Enthalpy, kJ/kg h_f	h_g	h_{fg}	Entropy, kJ/(kg K) s_f	s_g	s_{fg}
0.40	143.608	0.00108355	0.46238	604.22	2553.1	604.65	2738.1	2133.4	1.7765	6.8955	5.1190
0.42	145.375	0.00108544	0.44165	611.79	2554.8	612.25	2740.3	2128.0	1.7946	6.8791	5.0846
0.44	147.076	0.00108729	0.42274	619.10	2556.4	619.58	2742.4	2122.8	1.8120	6.8636	5.0516
0.46	148.716	0.00108908	0.40542	626.14	2557.9	626.64	2744.4	2117.7	1.8287	6.8487	5.0199
0.48	150.300	0.00109084	0.38950	632.95	2559.3	633.47	2746.3	2112.8	1.8448	6.8344	4.9895
0.50	151.831	0.00109255	0.37481	639.54	2560.7	640.09	2748.1	2108.0	1.8604	6.8207	4.9603
0.52	153.314	0.00109423	0.36120	645.93	2562.1	646.50	2749.9	2103.4	1.8754	6.8075	4.9321
0.54	154.753	0.00109587	0.34858	652.13	2563.3	652.72	2751.5	2098.8	1.8899	6.7948	4.9049
0.56	156.149	0.00109748	0.33682	658.16	2564.5	658.77	2753.1	2094.4	1.9040	6.7825	4.8786
0.58	157.506	0.00109905	0.32585	664.01	2565.7	664.65	2754.7	2090.0	1.9176	6.7707	4.8531
0.60	158.826	0.00110060	0.31558	669.72	2566.8	670.38	2756.1	2085.8	1.9308	6.7592	4.8284
0.62	160.112	0.00110212	0.30596	675.28	2567.9	675.96	2757.6	2081.6	1.9437	6.7482	4.8045
0.64	161.365	0.00110362	0.29691	680.70	2568.9	681.41	2758.9	2077.5	1.9562	6.7374	4.7813
0.66	162.587	0.00110509	0.28840	686.00	2570.0	686.73	2760.3	2073.5	1.9684	6.7270	4.7587
0.68	163.781	0.00110654	0.28036	691.17	2570.9	691.92	2761.5	2069.6	1.9802	6.7169	4.7367
0.70	164.946	0.00110796	0.27277	696.22	2571.9	697.00	2762.8	2065.8	1.9918	6.7071	4.7153
0.72	166.086	0.00110936	0.26559	701.17	2572.7	701.97	2763.9	2062.0	2.0031	6.6975	4.6944
0.74	167.200	0.00111075	0.25879	706.02	2573.6	706.84	2765.1	2058.2	2.0141	6.6882	4.6741
0.76	168.291	0.00111211	0.25233	710.76	2574.4	711.61	2766.2	2054.6	2.0248	6.6791	4.6543
0.78	169.360	0.00111346	0.24618	715.41	2575.3	716.28	2767.3	2051.0	2.0354	6.6703	4.6349
0.80	170.406	0.00111478	0.24034	719.97	2576.0	720.86	2768.3	2047.4	2.0457	6.6616	4.6160
0.82	171.433	0.00111609	0.23477	724.44	2576.8	725.36	2769.3	2043.9	2.0557	6.6532	4.5975
0.84	172.440	0.00111739	0.22946	728.84	2577.6	729.78	2770.3	2040.5	2.0656	6.6449	4.5793
0.86	173.428	0.00111867	0.22438	733.15	2578.2	734.11	2771.2	2037.1	2.0753	6.6369	4.5616
0.88	174.398	0.00111993	0.21953	737.38	2578.9	738.37	2772.1	2033.8	2.0847	6.6290	4.5443
0.90	175.350	0.00112118	0.21489	741.55	2579.6	742.56	2773.0	2030.5	2.0940	6.6213	4.5272
0.92	176.287	0.00112242	0.21044	745.65	2580.3	746.68	2773.9	2027.2	2.1032	6.6137	4.5106
0.94	177.207	0.00112364	0.20617	749.67	2580.9	750.73	2774.7	2024.0	2.1121	6.6063	4.4942
0.96	178.112	0.00112485	0.20208	753.64	2581.5	754.72	2775.5	2020.8	2.1209	6.5991	4.4782
0.98	179.002	0.00112605	0.19814	757.55	2582.1	758.65	2776.3	2017.7	2.1296	6.5920	4.4624
1.00	179.878	0.00112723	0.19436	761.39	2582.7	762.52	2777.1	2014.6	2.1381	6.5850	4.4470
1.05	182.009	0.00113014	0.18552	770.75	2584.1	771.94	2778.9	2007.0	2.1587	6.5681	4.4095
1.10	184.062	0.00113299	0.17745	779.78	2585.4	781.03	2780.6	1999.6	2.1785	6.5520	4.3735
1.15	186.043	0.00113577	0.17006	788.51	2586.6	789.82	2782.2	1992.4	2.1976	6.5365	4.3390
1.20	187.957	0.00113850	0.16326	796.96	2587.8	798.33	2783.7	1985.4	2.2159	6.5217	4.3058
1.25	189.809	0.00114118	0.15699	805.15	2588.9	806.58	2785.1	1978.6	2.2337	6.5074	4.2737
1.30	191.605	0.00114380	0.15119	813.11	2590.0	814.60	2786.5	1971.9	2.2508	6.4936	4.2428
1.35	193.347	0.00114638	0.14580	820.84	2590.9	822.39	2787.7	1965.3	2.2674	6.4803	4.2129
1.40	195.039	0.00114892	0.14078	828.36	2591.7	829.97	2788.8	1958.9	2.2835	6.4675	4.1839
1.45	196.685	0.00115141	0.13609	835.68	2592.6	837.35	2789.9	1952.6	2.2992	6.4550	4.1559
1.50	198.287	0.00115387	0.13171	842.83	2593.4	844.56	2791.0	1946.4	2.3143	6.4430	4.1286

Continued ...

p	T_{sat}	Volume, m^3/kg		Energy, kJ/kg		Enthalpy, kJ/kg			Entropy, kJ/(kg K)		
MPa	°C	v_f	v_g	u_f	u_g	h_f	h_g	h_{fg}	s_f	s_g	s_{fg}
1.50	198.287	0.00115387	0.13171	842.83	2593.4	844.56	2791.0	1946.4	2.3143	6.4430	4.1286
1.55	199.848	0.00115629	0.12760	849.80	2594.1	851.59	2791.9	1940.3	2.3291	6.4313	4.1022
1.60	201.370	0.00115868	0.12374	856.61	2594.8	858.46	2792.8	1934.4	2.3435	6.4199	4.0765
1.65	202.856	0.00116103	0.12010	863.25	2595.5	865.17	2793.7	1928.5	2.3575	6.4089	4.0514
1.70	204.307	0.00116336	0.11667	869.76	2596.2	871.74	2794.5	1922.7	2.3711	6.3981	4.0270
1.75	205.725	0.00116565	0.11343	876.13	2596.7	878.17	2795.2	1917.0	2.3845	6.3877	4.0032
1.80	207.112	0.00116792	0.11037	882.37	2597.2	884.47	2795.9	1911.4	2.3975	6.3775	3.9800
1.85	208.469	0.00117016	0.10746	888.49	2597.8	890.65	2796.6	1905.9	2.4102	6.3675	3.9573
1.90	209.798	0.00117238	0.10470	894.48	2598.3	896.71	2797.2	1900.5	2.4227	6.3578	3.9351
1.95	211.101	0.00117458	0.10208	900.37	2598.7	902.66	2797.8	1895.1	2.4348	6.3483	3.9135
2.0	212.377	0.00117675	0.099585	906.15	2599.1	908.50	2798.3	1889.8	2.4468	6.3390	3.8923
2.1	214.858	0.00118103	0.094938	917.39	2599.9	919.87	2799.3	1879.4	2.4699	6.3210	3.8511
2.2	217.249	0.00118523	0.090698	928.26	2600.6	930.87	2800.1	1869.2	2.4921	6.3038	3.8116
2.3	219.557	0.00118936	0.086815	938.79	2601.1	941.53	2800.8	1859.3	2.5136	6.2872	3.7736
2.4	221.789	0.00119343	0.083244	949.01	2601.6	951.87	2801.4	1849.6	2.5343	6.2712	3.7369
2.5	223.950	0.00119743	0.079949	958.92	2602.0	961.91	2801.9	1840.0	2.5543	6.2558	3.7015
2.6	226.046	0.00120138	0.076899	968.55	2602.4	971.67	2802.3	1830.7	2.5736	6.2409	3.6672
2.7	228.080	0.00120528	0.074066	977.93	2602.7	981.18	2802.7	1821.5	2.5924	6.2264	3.6340
2.8	230.057	0.00120913	0.071429	987.07	2602.9	990.46	2802.9	1812.4	2.6106	6.2124	3.6018
2.9	231.980	0.00121293	0.068968	995.99	2603.1	999.51	2803.1	1803.6	2.6283	6.1988	3.5705
3.0	233.853	0.00121669	0.066664	1004.6	2603.2	1008.3	2803.2	1794.8	2.6455	6.1856	3.5400
3.1	235.679	0.00122042	0.064504	1013.2	2603.2	1017.0	2803.2	1786.2	2.6623	6.1727	3.5104
3.2	237.459	0.00122410	0.062475	1021.5	2603.2	1025.4	2803.1	1777.7	2.6787	6.1602	3.4815
3.3	239.198	0.00122776	0.060564	1029.6	2603.1	1033.7	2803.0	1769.3	2.6946	6.1479	3.4533
3.4	240.897	0.00123138	0.058761	1037.6	2603.1	1041.8	2802.9	1761.0	2.7102	6.1360	3.4258
3.5	242.557	0.00123497	0.057058	1045.5	2602.9	1049.8	2802.6	1752.8	2.7254	6.1243	3.3989
3.6	244.182	0.00123854	0.055446	1053.1	2602.8	1057.6	2802.4	1744.8	2.7403	6.1129	3.3726
3.7	245.772	0.00124208	0.053918	1060.7	2602.6	1065.3	2802.1	1736.8	2.7549	6.1018	3.3469
3.8	247.330	0.00124559	0.052467	1068.1	2602.3	1072.8	2801.7	1728.9	2.7691	6.0908	3.3217
3.9	248.857	0.00124908	0.051089	1075.3	2602.1	1080.2	2801.3	1721.1	2.7831	6.0801	3.2970
4.0	250.354	0.00125256	0.049776	1082.5	2601.7	1087.5	2800.8	1713.3	2.7968	6.0696	3.2728
4.1	251.823	0.00125601	0.048525	1089.6	2601.3	1094.7	2800.3	1705.7	2.8102	6.0592	3.2491
4.2	253.264	0.00125944	0.047332	1096.4	2601.0	1101.7	2799.8	1698.1	2.8234	6.0491	3.2257
4.3	254.680	0.00126286	0.046192	1103.3	2600.6	1108.7	2799.2	1690.6	2.8363	6.0391	3.2028
4.4	256.070	0.00126626	0.045102	1109.9	2600.2	1115.5	2798.6	1683.1	2.8490	6.0293	3.1803
4.5	257.437	0.00126965	0.044059	1116.5	2599.6	1122.2	2797.9	1675.7	2.8615	6.0197	3.1582
4.6	258.780	0.00127302	0.043059	1123.0	2599.2	1128.9	2797.3	1668.4	2.8738	6.0102	3.1364
4.7	260.101	0.00127638	0.042100	1129.5	2598.6	1135.5	2796.5	1661.1	2.8859	6.0009	3.1150
4.8	261.402	0.00127973	0.041180	1135.8	2598.1	1141.9	2795.8	1653.9	2.8978	5.9917	3.0939
4.9	262.681	0.00128306	0.040296	1142.0	2597.5	1148.3	2795.0	1646.7	2.9095	5.9826	3.0731
5.0	263.941	0.00128639	0.039446	1148.2	2597.0	1154.6	2794.2	1639.6	2.9210	5.9737	3.0527

Continued ...

Water/Steam at $p = 0.10$ MPa ($T_{sat} = 99.606$°C)

T	v	u	h	s
°C	m^3/kg	kJ/kg	kJ/kg	kJ/kg K
*0	0.00100016	-0.04	0.06	-0.00015
5	0.00100003	21.02	21.12	0.07625
10	0.00100030	42.02	42.12	0.15108
15	0.00100090	62.98	63.08	0.22445
20	0.00100180	83.91	84.01	0.29646
25	0.00100296	104.82	104.92	0.36720
30	0.00100437	125.72	125.82	0.43673
35	0.00100600	146.62	146.72	0.50510
40	0.00100785	167.52	167.62	0.57237
45	0.00100988	188.41	188.51	0.63858
50	0.00101211	209.32	209.42	0.70377
55	0.00101452	230.23	230.33	0.76798
60	0.00101709	251.15	251.25	0.83125
65	0.00101984	272.08	272.18	0.89361
70	0.00102274	293.02	293.12	0.95509
75	0.00102581	313.98	314.08	1.0157
80	0.00102903	334.95	335.05	1.0755
85	0.00103241	355.95	356.05	1.1346
90	0.00103594	376.96	377.06	1.1928
95	0.00103962	398.00	398.10	1.2504
99.606	0.00104315	417.40	417.50	1.3028
99.606	1.6939	2505.5	2674.9	7.3588
100	1.6959	2506.2	2675.8	7.3610
105	1.7204	2514.1	2686.1	7.3885
110	1.7447	2521.8	2696.3	7.4155
115	1.7690	2529.6	2706.5	7.4418
120	1.7932	2537.3	2716.6	7.4678
125	1.8172	2545.0	2726.7	7.4932
130	1.8412	2552.6	2736.7	7.5183
135	1.8652	2560.2	2746.7	7.5429
140	1.8891	2567.8	2756.7	7.5672
145	1.9129	2575.4	2766.7	7.5911
150	1.9367	2582.9	2776.6	7.6148
155	1.9604	2590.5	2786.5	7.6380
160	1.9841	2598.0	2796.4	7.6610
165	2.0077	2605.5	2806.3	7.6838
170	2.0313	2613.1	2816.2	7.7062
175	2.0549	2620.6	2826.1	7.7284
180	2.0785	2628.1	2836.0	7.7503
185	2.1020	2635.6	2845.8	7.7719
190	2.1255	2643.1	2855.7	7.7934
195	2.1490	2650.7	2865.6	7.8146
200	2.1724	2658.3	2875.5	7.8356
210	2.2193	2673.3	2895.2	7.8769
220	2.2661	2688.4	2915.0	7.9174
230	2.3128	2703.5	2934.8	7.9572
240	2.3595	2718.7	2954.6	7.9962
250	2.4062	2733.9	2974.5	8.0346
260	2.4528	2749.1	2994.4	8.0723
270	2.4993	2764.5	3014.4	8.1094

T	v	u	h	s
°C	m^3/kg	kJ/kg	kJ/kg	kJ/kg K
270	2.4993	2764.5	3014.4	8.1094
280	2.5459	2779.8	3034.4	8.1459
290	2.5924	2795.2	3054.4	8.1818
300	2.6388	2810.6	3074.5	8.2172
310	2.6853	2826.2	3094.7	8.2520
320	2.7317	2841.7	3114.9	8.2864
330	2.7782	2857.3	3135.1	8.3202
340	2.8246	2873.0	3155.5	8.3536
350	2.8710	2888.7	3175.8	8.3866
360	2.9173	2904.6	3196.3	8.4191
370	2.9637	2920.3	3216.7	8.4512
380	3.0100	2936.3	3237.3	8.4829
390	3.0564	2952.3	3257.9	8.5142
400	3.1027	2968.3	3278.6	8.5452
410	3.1490	2984.4	3299.3	8.5757
420	3.1953	3000.6	3320.1	8.6059
430	3.2416	3016.7	3340.9	8.6358
440	3.2879	3033.1	3361.9	8.6653
450	3.3342	3049.4	3382.8	8.6946
460	3.3805	3065.8	3403.9	8.7235
470	3.4267	3082.3	3425.0	8.7521
480	3.4730	3098.9	3446.2	8.7804
490	3.5193	3115.5	3467.4	8.8084
500	3.5655	3132.1	3488.7	8.8361
520	3.6580	3165.8	3531.6	8.8908
540	3.7505	3199.6	3574.7	8.9445
560	3.8430	3233.7	3618.0	8.9972
580	3.9354	3268.2	3661.7	9.0489
600	4.0279	3302.8	3705.6	9.0998
620	4.1203	3337.8	3749.8	9.1499
640	4.2127	3373.0	3794.3	9.1991
660	4.3052	3408.5	3839.0	9.2476
680	4.3976	3444.2	3884.0	9.2954
700	4.4900	3480.4	3929.4	9.3424
720	4.5824	3516.8	3975.0	9.3888
740	4.6747	3553.4	4020.9	9.4345
760	4.7671	3590.3	4067.0	9.4797
780	4.8595	3627.6	4113.5	9.5242
800	4.9519	3665.0	4160.2	9.5681
820	5.0443	3702.8	4207.2	9.6115
840	5.1366	3740.8	4254.5	9.6544
860	5.2290	3779.2	4302.1	9.6968
880	5.3213	3817.8	4349.9	9.7386
900	5.4137	3856.6	4398.0	9.7800
920	5.5061	3895.8	4446.4	9.8209
940	5.5984	3935.2	4495.0	9.8613
960	5.6908	3974.8	4543.9	9.9013
980	5.7831	4014.8	4593.1	9.9408
1000	5.8754	4055.1	4642.6	9.9800

Water/Steam at $p = 4.0$ MPa ($T_{sat} = 250.354$°C)

T	v	u	h	s
°C	m^3/kg	kJ/kg	kJ/kg	kJ/kg K
0	0.00099819	0.03	4.02	0.00009
5	0.00099813	21.00	24.99	0.07617
10	0.00099844	41.92	45.91	0.15072
15	0.00099909	62.80	66.80	0.22385
20	0.00100001	83.67	87.67	0.29564
25	0.00100120	104.52	108.52	0.36619
30	0.00100263	125.36	129.37	0.43553
35	0.00100427	146.20	150.22	0.50374
40	0.00100612	167.05	171.07	0.57085
45	0.00100816	187.89	191.92	0.63691
50	0.00101038	208.74	212.78	0.70196
55	0.00101277	229.59	233.64	0.76604
60	0.00101534	250.46	254.52	0.82918
65	0.00101807	271.34	275.41	0.89141
70	0.00102095	292.23	296.31	0.95277
75	0.00102399	313.13	317.23	1.0133
80	0.00102719	334.05	338.16	1.0730
85	0.00103054	354.99	359.11	1.1319
90	0.00103403	375.94	380.08	1.1900
95	0.00103768	396.93	401.08	1.2475
100	0.00104148	417.93	422.10	1.3042
105	0.00104543	438.97	443.15	1.3602
110	0.00104953	460.02	464.22	1.4156
115	0.00105379	481.12	485.34	1.4703
120	0.00105820	502.26	506.49	1.5245
125	0.00106277	523.43	527.68	1.5780
130	0.00106751	544.64	548.91	1.6310
135	0.00107240	565.90	570.19	1.6835
140	0.00107747	587.22	591.53	1.7354
145	0.00108272	608.58	612.91	1.7869
150	0.00108814	630.01	634.36	1.8379
155	0.00109375	651.49	655.87	1.8884
160	0.00109956	673.05	677.45	1.9385
165	0.00110556	694.69	699.11	1.9882
170	0.00111178	716.39	720.84	2.0376
175	0.00111821	738.19	742.66	2.0865
180	0.00112487	760.07	764.57	2.1352
185	0.00113177	782.05	786.58	2.1835
190	0.00113893	804.13	808.69	2.2315
195	0.00114635	826.33	830.92	2.2792
200	0.00115405	848.65	853.27	2.3267
210	0.00117038	893.67	898.35	2.4210
220	0.00118807	939.29	944.04	2.5146
230	0.00120733	985.59	990.42	2.6077
240	0.00122842	1032.7	1037.6	2.7005
250	0.00125169	1080.8	1085.8	2.7935
250.354	0.00125256	1082.5	1087.5	2.7968
250.354	0.0497760	2601.7	2800.8	6.0696
260	0.0517770	2630.0	2837.1	6.1383
270	0.0536930	2656.4	2871.2	6.2016

T	v	u	h	s
°C	m^3/kg	kJ/kg	kJ/kg	kJ/kg K
270	0.0536930	2656.4	2871.2	6.2016
280	0.0554970	2680.9	2902.9	6.2595
290	0.0572170	2704.1	2933.0	6.3133
300	0.0588700	2726.2	2961.7	6.3639
310	0.0604680	2747.5	2989.4	6.4118
320	0.0620210	2768.2	3016.3	6.4576
330	0.0635360	2788.4	3042.5	6.5014
340	0.0650190	2808.0	3068.1	6.5435
350	0.0664730	2827.4	3093.3	6.5843
360	0.0679030	2846.5	3118.1	6.6238
370	0.0693110	2865.4	3142.6	6.6621
380	0.0707010	2884.0	3166.8	6.6994
390	0.0720730	2902.4	3190.7	6.7358
400	0.0734310	2920.8	3214.5	6.7714
410	0.0747760	2939.0	3238.1	6.8061
420	0.0761080	2957.1	3261.5	6.8402
430	0.0774290	2975.1	3284.8	6.8736
440	0.0787410	2993.0	3308.0	6.9064
450	0.0800430	3011.0	3331.2	6.9386
460	0.0813370	3028.9	3354.2	6.9703
470	0.0826230	3046.7	3377.2	7.0015
480	0.0839020	3064.6	3400.2	7.0321
490	0.0851750	3082.4	3423.1	7.0624
500	0.0864420	3100.2	3446.0	7.0922
520	0.0889590	3136.0	3491.8	7.1506
540	0.0914570	3171.7	3537.5	7.2075
560	0.0939380	3207.4	3583.2	7.2631
580	0.0964050	3243.4	3629.0	7.3174
600	0.0988590	3279.5	3674.9	7.3705
620	0.10130	3315.7	3720.9	7.4226
640	0.10373	3352.1	3767.0	7.4737
660	0.10616	3388.6	3813.2	7.5238
680	0.10857	3425.4	3859.7	7.5730
700	0.11098	3462.4	3906.3	7.6214
720	0.11338	3499.6	3953.1	7.6690
740	0.11577	3537.0	4000.1	7.7159
760	0.11816	3574.7	4047.3	7.7620
780	0.12054	3612.5	4094.7	7.8074
800	0.12292	3650.6	4142.3	7.8523
820	0.12530	3689.0	4190.2	7.8964
840	0.12767	3727.6	4238.3	7.9400
860	0.13003	3766.5	4286.6	7.9830
880	0.13240	3805.5	4335.1	8.0255
900	0.13476	3844.9	4383.9	8.0674
920	0.13712	3884.4	4432.9	8.1088
940	0.13947	3924.2	4482.1	8.1498
960	0.14183	3964.3	4531.6	8.1902
980	0.14418	4004.6	4581.3	8.2302
1000	0.14652	4045.1	4631.2	8.2697

Water/Steam at $p = 4.5$ MPa ($T_{sat} = 257.437$°C)

T	v	u	h	s
°C	m^3/kg	kJ/kg	kJ/kg	kJ/kg K
0	0.00099793	0.04	4.53	0.00011
5	0.00099789	21.00	25.49	0.07615
10	0.00099821	41.91	46.40	0.15067
15	0.00099885	62.79	67.28	0.22377
20	0.00099979	83.64	88.14	0.29554
25	0.00100098	104.49	108.99	0.36605
30	0.00100240	125.32	129.83	0.43538
35	0.00100405	146.15	150.67	0.50356
40	0.00100590	166.98	171.51	0.57066
45	0.00100794	187.82	192.36	0.63670
50	0.00101016	208.66	213.21	0.70173
55	0.00101255	229.51	234.07	0.76579
60	0.00101511	250.37	254.94	0.82892
65	0.00101784	271.24	275.82	0.89113
70	0.00102072	292.13	296.72	0.95247
75	0.00102376	313.02	317.63	1.0130
80	0.00102696	333.94	338.56	1.0727
85	0.00103030	354.86	359.50	1.1315
90	0.00103379	375.82	380.47	1.1897
95	0.00103744	396.79	401.46	1.2471
100	0.00104123	417.78	422.47	1.3038
105	0.00104517	438.82	443.52	1.3598
110	0.00104927	459.87	464.59	1.4152
115	0.00105352	480.96	485.70	1.4699
120	0.00105793	502.08	506.84	1.5240
125	0.00106249	523.24	528.02	1.5776
130	0.00106721	544.45	549.25	1.6305
135	0.00107210	565.71	570.53	1.6830
140	0.00107716	587.00	591.85	1.7349
145	0.00108240	608.36	613.23	1.7864
150	0.00108781	629.77	634.67	1.8373
155	0.00109341	651.26	656.18	1.8879
160	0.00109920	672.80	677.75	1.9379
165	0.00110519	694.42	699.39	1.9876
170	0.00111139	716.12	721.12	2.0369
175	0.00111781	737.90	742.93	2.0859
180	0.00112445	759.77	764.83	2.1345
185	0.00113134	781.74	786.83	2.1827
190	0.00113847	803.81	808.93	2.2307
195	0.00114587	825.98	831.14	2.2784
200	0.00115355	848.28	853.47	2.3259
210	0.00116983	893.27	898.53	2.4201
220	0.00118745	938.84	944.18	2.5136
230	0.00120663	985.09	990.52	2.6067
240	0.00122763	1032.2	1037.7	2.6994
250	0.00125077	1080.2	1085.8	2.7922
257.437	0.00126965	1116.5	1122.2	2.8615
257.437	0.0440590	2599.6	2797.9	6.0197
260	0.0445720	2608.0	2808.6	6.0397
270	0.0464510	2637.7	2846.7	6.1105

T	v	u	h	s
°C	m^3/kg	kJ/kg	kJ/kg	kJ/kg K
270	0.0464510	2637.7	2846.7	6.1105
280	0.0481860	2664.5	2881.3	6.1737
290	0.0498210	2689.4	2913.6	6.2316
300	0.0513780	2713.0	2944.2	6.2854
310	0.0528730	2735.5	2973.4	6.3359
320	0.0543170	2757.2	3001.6	6.3838
330	0.0557200	2778.2	3028.9	6.4295
340	0.0570870	2798.6	3055.5	6.4732
350	0.0584230	2818.6	3081.5	6.5153
360	0.0597330	2838.2	3107.0	6.5560
370	0.0610210	2857.5	3132.1	6.5953
380	0.0622880	2876.6	3156.9	6.6336
390	0.0635380	2895.5	3181.4	6.6708
400	0.0647720	2914.1	3205.6	6.7070
410	0.0659910	2932.7	3229.7	6.7425
420	0.0671990	2951.1	3253.5	6.7771
430	0.0683940	2969.4	3277.2	6.8111
440	0.0695800	2987.7	3300.8	6.8443
450	0.0707560	3005.8	3324.2	6.8770
460	0.0719240	3023.9	3347.6	6.9091
470	0.0730830	3042.0	3370.9	6.9406
480	0.0742360	3060.0	3394.1	6.9716
490	0.0753810	3078.0	3417.2	7.0022
500	0.0765210	3096.1	3440.4	7.0323
520	0.0787840	3132.0	3486.5	7.0912
540	0.0810270	3168.0	3532.6	7.1486
560	0.0832530	3204.0	3578.6	7.2046
580	0.0854640	3240.1	3624.7	7.2592
600	0.0876620	3276.4	3670.9	7.3127
620	0.0898480	3312.8	3717.1	7.3650
640	0.0920240	3349.3	3763.4	7.4163
660	0.0941910	3386.0	3809.9	7.4666
680	0.0963490	3422.9	3856.5	7.5161
700	0.0985000	3460.1	3903.3	7.5646
720	0.10064	3497.3	3950.2	7.6124
740	0.10278	3534.9	3997.4	7.6594
760	0.10491	3572.6	4044.7	7.7057
780	0.10704	3610.6	4092.3	7.7512
800	0.10916	3648.8	4140.0	7.7962
820	0.11128	3687.2	4188.0	7.8404
840	0.11340	3725.9	4236.2	7.8841
860	0.11551	3764.8	4284.6	7.9272
880	0.11762	3803.9	4333.2	7.9698
900	0.11972	3843.4	4382.1	8.0118
920	0.12182	3882.9	4431.1	8.0533
940	0.12392	3922.9	4480.5	8.0942
960	0.12602	3962.9	4530.0	8.1348
980	0.12811	4003.3	4579.8	8.1748
1000	0.13020	4043.9	4629.8	8.2144

Water/Steam at $p = 12.0$ MPa ($T_{sat} = 324.675$°C)

T	v	u	h	s
°C	m^3/kg	kJ/kg	kJ/kg	kJ/kg K
0	0.00099422	0.14	12.07	0.00039
5	0.00099429	20.94	32.87	0.07585
10	0.00099471	41.70	53.64	0.14987
15	0.00099543	62.45	74.40	0.22252
20	0.00099642	83.18	95.14	0.29390
25	0.00099766	103.92	115.89	0.36406
30	0.00099911	124.64	136.63	0.43305
35	0.00100078	145.36	157.37	0.50093
40	0.00100263	166.10	178.13	0.56773
45	0.00100467	186.83	198.89	0.63350
50	0.00100689	207.58	219.66	0.69828
55	0.00100927	228.33	240.44	0.76209
60	0.00101181	249.09	261.23	0.82497
65	0.00101450	269.86	282.03	0.88695
70	0.00101735	290.64	302.85	0.94806
75	0.00102035	311.44	323.68	1.0083
80	0.00102349	332.25	344.53	1.0678
85	0.00102678	353.08	365.40	1.1265
90	0.00103021	373.92	386.28	1.1844
95	0.00103379	394.78	407.19	1.2416
100	0.00103751	415.67	428.12	1.2980
105	0.00104138	436.58	449.08	1.3538
110	0.00104538	457.53	470.07	1.4090
115	0.00104954	478.50	491.09	1.4635
120	0.00105384	499.50	512.15	1.5174
125	0.00105830	520.54	533.24	1.5707
130	0.00106291	541.62	554.37	1.6234
135	0.00106767	562.74	575.55	1.6756
140	0.00107259	583.90	596.77	1.7273
145	0.00107768	605.11	618.04	1.7785
150	0.00108294	626.37	639.37	1.8292
155	0.00108837	647.70	660.76	1.8794
160	0.00109398	669.08	682.21	1.9293
165	0.00109978	690.52	703.72	1.9786
170	0.00110577	712.04	725.31	2.0276
175	0.00111197	733.64	746.98	2.0763
180	0.00111837	755.31	768.73	2.1245
185	0.00112500	777.07	790.57	2.1724
190	0.00113185	798.92	812.50	2.2201
195	0.00113895	820.86	834.53	2.2674
200	0.00114630	842.91	856.67	2.3144
210	0.00116182	887.35	901.29	2.4077
220	0.00117855	932.30	946.44	2.5002
230	0.00119665	977.84	992.20	2.5921
240	0.00121633	1024.0	1038.6	2.6835
250	0.00123783	1071.0	1085.9	2.7747
260	0.00126150	1119.0	1134.1	2.8660
270	0.00128778	1167.9	1183.4	2.9576

T	v	u	h	s
°C	m^3/kg	kJ/kg	kJ/kg	kJ/kg K
270	0.00128778	1167.9	1183.4	2.9576
280	0.00131727	1218.3	1234.1	3.0501
290	0.00135083	1270.4	1286.6	3.1440
300	0.00138976	1324.5	1341.2	3.2401
310	0.00143613	1381.5	1398.7	3.3397
320	0.00149366	1442.6	1460.5	3.4447
324.675	0.00152630	1473.2	1491.5	3.4967
324.675	0.0142640	2514.2	2685.4	5.4939
330	0.0150210	2547.9	2728.2	5.5651
340	0.0162100	2599.1	2793.6	5.6727
350	0.0172210	2641.4	2848.1	5.7609
360	0.0181210	2678.4	2895.9	5.8371
370	0.0189430	2711.9	2939.2	5.9049
380	0.0197060	2742.7	2979.2	5.9665
390	0.0204240	2771.5	3016.6	6.0234
400	0.0211060	2798.7	3052.0	6.0764
410	0.0217580	2824.7	3085.8	6.1262
420	0.0223850	2849.7	3118.3	6.1734
430	0.0229900	2873.8	3149.7	6.2184
440	0.0235770	2897.2	3180.1	6.2614
450	0.0241490	2920.0	3209.8	6.3028
460	0.0247070	2942.4	3238.9	6.3427
470	0.0252520	2964.3	3267.3	6.3812
480	0.0257870	2985.9	3295.3	6.4186
490	0.0263120	3007.1	3322.8	6.4549
500	0.0268280	3028.1	3350.0	6.4903
520	0.0278370	3069.4	3403.4	6.5585
540	0.0288210	3109.9	3455.8	6.6237
560	0.0297820	3150.0	3507.4	6.6864
580	0.0307250	3189.7	3558.4	6.7469
600	0.0316510	3229.1	3608.9	6.8054
620	0.0325640	3268.3	3659.1	6.8622
640	0.0334650	3307.4	3709.0	6.9175
660	0.0343560	3346.4	3758.7	6.9713
680	0.0352370	3385.4	3808.2	7.0239
700	0.0361090	3424.4	3857.7	7.0753
720	0.0369750	3463.5	3907.2	7.1256
740	0.0378330	3502.6	3956.6	7.1748
760	0.0386850	3541.8	4006.0	7.2232
780	0.0395320	3581.2	4055.6	7.2706
800	0.0403750	3620.6	4105.1	7.3173
820	0.0412120	3660.3	4154.8	7.3631
840	0.0420450	3700.1	4204.6	7.4083
860	0.0428750	3740.0	4254.5	7.4527
880	0.0437010	3780.1	4304.5	7.4965
900	0.0445240	3820.4	4354.7	7.5396
920	0.0453440	3860.9	4405.0	7.5821
940	0.0461610	3901.6	4455.5	7.6241
960	0.0469760	3942.4	4506.1	7.6655
980	0.0477890	3983.5	4557.0	7.7064
1000	0.0485990	4024.8	4608.0	7.7467

Water/Steam at $p = 22.0$ MPa ($T_{sat} = 373.705$°C)

T	v	u	h	s
°C	m^3/kg	kJ/kg	kJ/kg	kJ/kg K
0	0.00098941	0.24	22.01	0.00046
5	0.00098963	20.84	42.61	0.07521
10	0.00099017	41.43	63.21	0.14861
15	0.00099099	62.01	83.81	0.22072
20	0.00099205	82.58	104.41	0.29161
25	0.00099334	103.17	125.02	0.36132
30	0.00099484	123.75	145.64	0.42990
35	0.00099653	144.35	166.27	0.49739
40	0.00099840	164.95	186.91	0.56383
45	0.00100044	185.55	207.56	0.62925
50	0.00100264	206.16	228.22	0.69370
55	0.00100500	226.79	248.90	0.75719
60	0.00100752	247.42	269.59	0.81976
65	0.00101018	268.07	290.29	0.88144
70	0.00101298	288.72	311.01	0.94226
75	0.00101593	309.39	331.74	1.0022
80	0.00101901	330.07	352.49	1.0614
85	0.00102223	350.77	373.26	1.1198
90	0.00102559	371.49	394.05	1.1775
95	0.00102908	392.21	414.85	1.2344
100	0.00103271	412.96	435.68	1.2906
105	0.00103648	433.74	456.54	1.3461
110	0.00104038	454.53	477.42	1.4009
115	0.00104442	475.35	498.33	1.4551
120	0.00104860	496.20	519.27	1.5088
125	0.00105292	517.08	540.24	1.5618
130	0.00105738	537.99	561.25	1.6142
135	0.00106199	558.95	582.31	1.6661
140	0.00106675	579.93	603.40	1.7175
145	0.00107166	600.96	624.54	1.7683
150	0.00107673	622.04	645.73	1.8187
155	0.00108196	643.17	666.97	1.8686
160	0.00108735	664.35	688.27	1.9181
165	0.00109292	685.59	709.63	1.9671
170	0.00109866	706.88	731.05	2.0157
175	0.00110458	728.24	752.54	2.0639
180	0.00111070	749.67	774.11	2.1118
185	0.00111701	771.18	795.75	2.1593
190	0.00112354	792.76	817.48	2.2065
195	0.00113027	814.42	839.29	2.2533
200	0.00113724	836.18	861.20	2.2999
210	0.00115189	879.97	905.31	2.3921
220	0.00116759	924.19	949.88	2.4834
230	0.00118448	968.90	994.96	2.5739
240	0.00120269	1014.1	1040.6	2.6638
250	0.00122242	1060.0	1086.9	2.7532
260	0.00124390	1106.6	1134.0	2.8423
270	0.00126743	1154.1	1182.0	2.9315

T	v	u	h	s
°C	m^3/kg	kJ/kg	kJ/kg	kJ/kg K
270	0.00126743	1154.1	1182.0	2.9315
280	0.00129338	1202.5	1231.0	3.0209
290	0.00132227	1252.2	1281.3	3.1110
300	0.00135478	1303.2	1333.0	3.2021
310	0.00139190	1356.1	1386.7	3.2948
320	0.00143509	1411.1	1442.7	3.3900
330	0.00148666	1469.1	1501.8	3.4889
340	0.00155060	1531.3	1565.4	3.5934
350	0.00163487	1599.9	1635.9	3.7075
360	0.00176012	1680.7	1719.4	3.8404
370	0.00202860	1797.9	1842.5	4.0332
373.705	0.00270440	1951.8	2011.3	4.2945
373.705	0.00364750	2092.9	2173.1	4.5446
380	0.00612340	2369.8	2504.5	5.0555
390	0.00737870	2481.6	2643.9	5.2675
400	0.00825560	2554.2	2735.8	5.4051
410	0.00897020	2611.1	2808.4	5.5122
420	0.00958930	2659.0	2870.0	5.6018
430	0.0101440	2701.3	2924.5	5.6798
440	0.0106510	2739.4	2973.7	5.7494
450	0.0111230	2774.5	3019.2	5.8127
460	0.0115650	2807.3	3061.7	5.8710
470	0.0119850	2838.1	3101.8	5.9254
480	0.0123850	2867.5	3140.0	5.9764
490	0.0127680	2895.6	3176.5	6.0246
500	0.0131380	2922.8	3211.8	6.0705
520	0.0138420	2974.5	3279.0	6.1563
540	0.0145080	3023.6	3342.8	6.2358
560	0.0151440	3070.8	3404.0	6.3102
580	0.0157550	3116.7	3463.3	6.3805
600	0.0163470	3161.4	3521.0	6.4473
620	0.0169210	3205.1	3577.4	6.5113
640	0.0174810	3248.3	3632.9	6.5727
660	0.0180280	3291.0	3687.6	6.6319
680	0.0185650	3333.2	3741.6	6.6892
700	0.0190920	3375.1	3795.1	6.7447
720	0.0196110	3416.8	3848.2	6.7988
740	0.0201220	3458.3	3901.0	6.8514
760	0.0206270	3499.7	3953.5	6.9027
780	0.0211260	3541.0	4005.8	6.9529
800	0.0216200	3582.4	4058.0	7.0020
820	0.0221090	3623.7	4110.1	7.0500
840	0.0225940	3665.0	4162.1	7.0972
860	0.0230740	3706.5	4214.1	7.1435
880	0.0235510	3747.9	4266.0	7.1889
900	0.0240250	3789.4	4318.0	7.2336
920	0.0244950	3831.2	4370.1	7.2776
940	0.0249630	3873.0	4422.2	7.3209
960	0.0254280	3914.9	4474.3	7.3636
980	0.0258910	3957.0	4526.6	7.4056
1000	0.0263520	3999.2	4578.9	7.4470

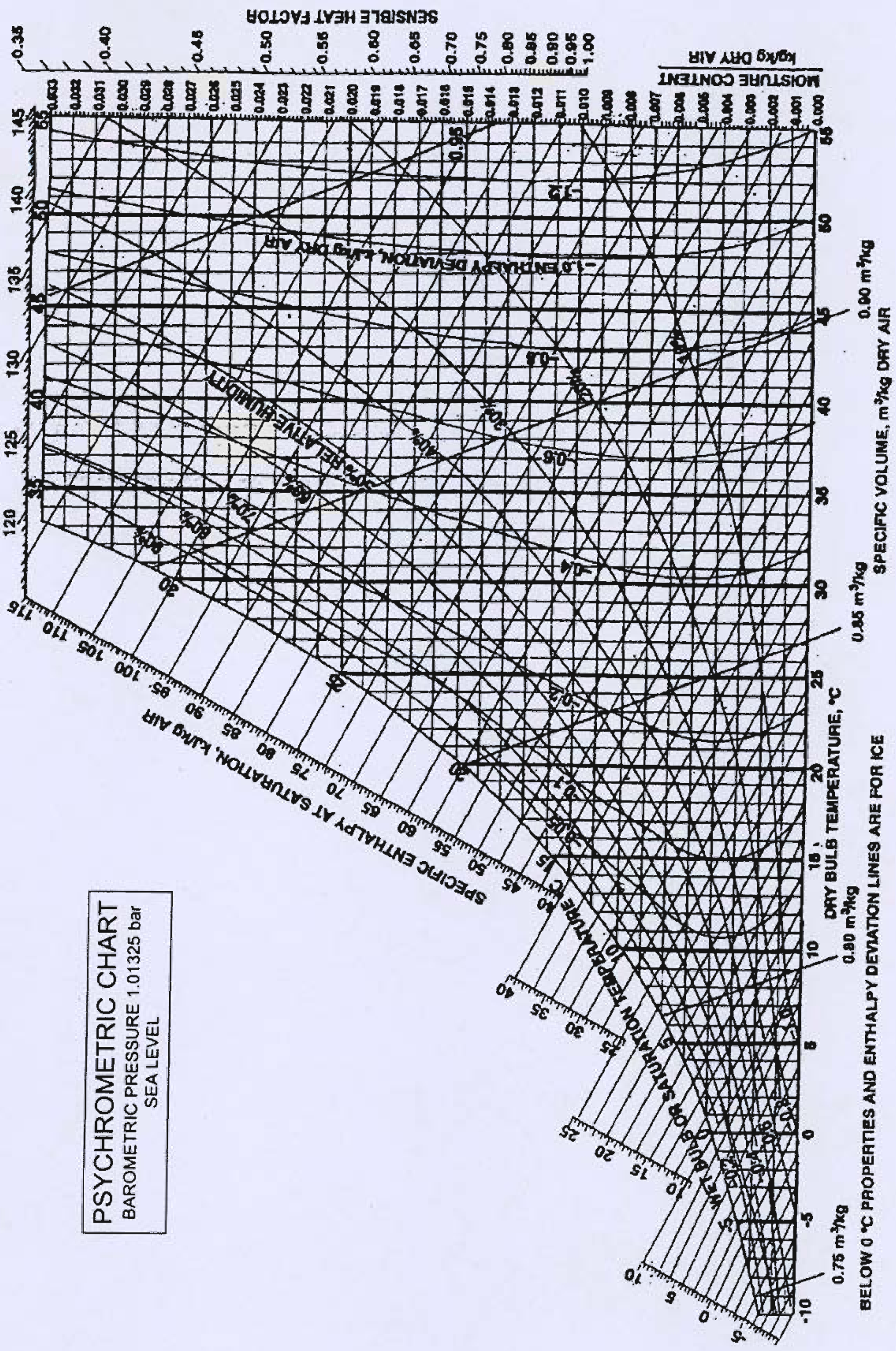
Water/Steam at $p = 25.0$ MPa

T	v	u	h	s
°C	m³/kg	kJ/kg	kJ/kg	kJ/kg K
0	0.00098800	0.26	24.96	0.00041
5	0.00098826	20.80	45.51	0.07496
10	0.00098884	41.34	66.06	0.14819
15	0.00098968	61.88	86.62	0.22015
20	0.00099077	82.41	107.18	0.29089
25	0.00099207	102.95	127.75	0.36047
30	0.00099358	123.49	148.33	0.42894
35	0.00099527	144.05	168.93	0.49632
40	0.00099715	164.60	189.53	0.56265
45	0.00099919	185.17	210.15	0.62798
50	0.00100139	205.76	230.79	0.69233
55	0.00100375	226.34	251.43	0.75573
60	0.00100625	246.93	272.09	0.81821
65	0.00100890	267.55	292.77	0.87981
70	0.00101170	288.17	313.46	0.94054
75	0.00101463	308.79	334.16	1.0004
80	0.00101769	329.44	354.88	1.0595
85	0.00102090	350.10	375.62	1.1178
90	0.00102423	370.77	396.38	1.1754
95	0.00102770	391.46	417.15	1.2322
100	0.00103130	412.17	437.95	1.2883
105	0.00103504	432.90	458.78	1.3438
110	0.00103891	453.66	479.63	1.3986
115	0.00104292	474.43	500.50	1.4527
120	0.00104706	495.23	521.41	1.5062
125	0.00105134	516.07	542.35	1.5591
130	0.00105577	536.94	563.33	1.6115
135	0.00106033	557.84	584.35	1.6633
140	0.00106505	578.78	605.41	1.7146
145	0.00106991	599.76	626.51	1.7654
150	0.00107492	620.79	647.66	1.8156
155	0.00108009	641.86	668.86	1.8654
160	0.00108543	662.97	690.11	1.9148
165	0.00109093	684.16	711.43	1.9637
170	0.00109660	705.39	732.80	2.0122
175	0.00110245	726.69	754.25	2.0604
180	0.00110849	748.05	775.76	2.1081
185	0.00111472	769.48	797.35	2.1555
190	0.00112115	790.99	819.02	2.2025
195	0.00112778	812.58	840.77	2.2492
200	0.00113464	834.24	862.61	2.2956
210	0.00114906	877.86	906.59	2.3876
220	0.00116449	921.89	951.00	2.4786
230	0.00118104	966.36	995.89	2.5687
240	0.00119887	1011.3	1041.3	2.6582
250	0.00121814	1056.9	1087.4	2.7471
260	0.00123906	1103.2	1134.2	2.8357
270	0.00126190	1150.4	1181.9	2.9242

T	v	u	h	s
°C	m³/kg	kJ/kg	kJ/kg	kJ/kg K
270	0.00126190	1150.4	1181.9	2.9242
280	0.00128699	1198.3	1230.5	3.0129
290	0.00131478	1247.3	1280.2	3.1020
300	0.00134590	1297.7	1331.3	3.1919
310	0.00138100	1349.6	1384.1	3.2832
320	0.00142150	1403.4	1438.9	3.3764
330	0.00146900	1459.7	1496.4	3.4726
340	0.00152640	1519.3	1557.5	3.5731
350	0.00159880	1583.9	1623.9	3.6804
360	0.00169690	1656.2	1698.6	3.7993
370	0.00185030	1743.5	1789.8	3.9423
380	0.00221820	1880.2	1935.7	4.1671
390	0.00464740	2279.5	2395.7	4.8660
400	0.00600470	2428.5	2578.6	5.1400
410	0.00688330	2515.0	2687.1	5.3000
420	0.00757920	2579.9	2769.4	5.4197
430	0.00817250	2633.5	2837.8	5.5176
440	0.00869860	2679.8	2897.3	5.6016
450	0.00917630	2721.2	2950.6	5.6759
460	0.00961760	2759.0	2999.4	5.7428
470	0.0100300	2793.9	3044.6	5.8042
480	0.0104190	2826.7	3087.2	5.8610
490	0.0107890	2857.8	3127.5	5.9142
500	0.0111430	2887.3	3165.9	5.9642
520	0.0118110	2943.1	3238.4	6.0569
540	0.0124360	2995.6	3306.5	6.1416
560	0.0130290	3045.5	3371.2	6.2202
580	0.0135950	3093.4	3433.3	6.2940
600	0.0141400	3140.0	3493.5	6.3637
620	0.0146670	3185.4	3552.1	6.4300
640	0.0151790	3229.9	3609.4	6.4935
660	0.0156780	3273.8	3665.7	6.5545
680	0.0161650	3317.1	3721.2	6.6133
700	0.0166430	3359.9	3776.0	6.6702
720	0.0171130	3402.4	3830.2	6.7254
740	0.0175740	3444.8	3884.1	6.7791
760	0.0180290	3486.9	3937.6	6.8313
780	0.0184780	3528.9	3990.8	6.8823
800	0.0189220	3570.8	4043.8	6.9322
820	0.0193610	3612.6	4096.6	6.9810
840	0.0197950	3654.4	4149.3	7.0287
860	0.0202250	3696.3	4201.9	7.0756
880	0.0206520	3738.2	4254.5	7.1216
900	0.0210750	3780.2	4307.1	7.1668
920	0.0214960	3822.2	4359.6	7.2112
940	0.0219130	3864.4	4412.2	7.2549
960	0.0223280	3906.6	4464.8	7.2979
980	0.0227400	3949.0	4517.5	7.3403
1000	0.0231500	3991.5	4570.2	7.3820

Do not write your Roll No. on this Sheet

Ref. Point for S.H.F. is 25°C, 50% R.H.



Space for Rough Work

Space for Rough Work

Space for Rough Work