For the following multiple choice questions, choose the *most correct* answer. For show the detailed solution for each question to guarantee the grade. (2 points

[1-2]: In center of pressure experiment, if the plane surface is partially immersed, the water leve the width of immersed surface b=7.5 cm. ($\gamma_{water} = 9810\ N/m^3$). Answer Problems (1-2):

1) The hydrostatic pressure force on the plane surface is:
   a. 0.59 N
   b. 0.33 N
   c. 0.92 N
   d. 0.15 N
   e. None of the above

2) The theoretical center of pressure measured from the surface of the water is:
   a. 3.33 cm
   b. 1.33 cm
   c. 2.67 cm
   d. 2.00 cm
   e. None of the above

3) Thermal conductivity of a material is

a. The resistance of a material to conduct heat through
b. The ability of a solid material to store heat
c. The ability of a material to conduct heat
d. A measure of liquids ability to convect heat
e. All of the above

[4-5] In the losses experiment, if the following data were measured: mass flow rate of 0.2 kg/s, density of wate is $\rho = 1000\ kg/m^3$, diameter of small pipe size 14 mm, dynamic viscosity of water is $\mu = 1 \times 10^{-3} N.s/m^2$, roughness of the pipe surface is $\varepsilon = 0.0015$ mm. Answer Problems (4-5):

4) The Reynolds number is:
   a. 2100.12
   b. 18189.14
   c. 57142.86
   d. 36378.27
   e. None of the above

5) The friction factor is:
   a. 0.018
   b. 0.034
   c. 0.043
   d. 0.027
   e. None of the above

6) In impact of water jet experiment, the water density is 1000 kg/m^3, the mass flow rate is 0.4 kg/s, the height of vane above nozzle outlet is 0.04 m and the diameter of nozzle is 0.01 m. If a hemispherical cup is used, the theoretical water jet force is:

a. 6.30 N
b. 4.01 N
c. 7.64 N
d. 5.10 N
e. None of the above

7) In "Flow through a nozzle" experiment, one of the following statements is correct:

a. Throat pressure is minimum pressure reading inside the nozzle
b. Throat pressure is maximum pressure reading inside the nozzle
c. Mass flow rate is minimum if the nozzle is choked
d. Throat pressure is the gage pressure reading of the air supply tank
e. None of the above

8) Only one of the following statement is correct with regards to the Flow through a nozzle experiment:

a. As pressure increases in the direction of the flow in the nozzle, velocity decreases
b. Both pressure and velocity decrease through the nozzle
c. Mass flow rate of the air increases as the area of the nozzle decreases
d. Cross section area of the nozzle increases in the direction of the flow
e. As the velocity increases in the direction of the flow, pressure decreases

9) In flow through a nozzle experiment, the stagnation "chest" absolute pressure is 290 kPa, the stagnation "chest" temperature is 18 °C, the air gas constant is 0.287 kJ/kg. K, the air specific heat ratio is 1.4, the nozzle throat area is $9.16 \times 10^{-6}\ m^2$ and the throat absolute pressure is 265 kPa. The mass flow rate at the nozzle throat is:

a. 3.63×10^{-3} kg/s
b. 2.92×10^{-3} kg/s
c. 1.84×10^{-3} kg/s
d. 2.34×10^{-3} kg/s
e. None of the above

10) In losses in pipes experiment, pressure change in globe valve is measured using:

a. Pressurized piezometer tube	b. Piezoelectric gage pressure	c. U-tube manometer	d. Pitot-static tube	e. None of the above

11) The type of the nozzle used in the "flow through a nozzle" experiment is:

a. Divergent-Parallel	b. Convergent-Parallel	c. Convergent-divergent	d. Divergent-divergent	e. None of the above

12) In thermal conductivity experiment: the copper specimen diameter is 0.025 m, the copper specimen length is 50 mm, the water density is 1000 kg/m^3, the specific heat of water is 4.18 kJ/kg°C, the mass flow rate is 2.75×10^{-4} kg/s, the inlet and outlet water temperatures are 15°C and 25°C respectively, the copper specimen ends temperatures are 162.5°C and 170°C. The rate of heat transfer through the copper specimen is:

a. 34.49 W
b. 22.99 W
c. 28.74 W
d. 17.24 W
e. None of the above

13) In pump characteristics experiment, for the centrifugal pump the following data were recorded: the suction pressure is 0 bar, the delivery pressure is 0.7 bar, the volume flow rate is 3.21×10^{-3} m^3/s, the water density is 1000 kg/m^3, the spring load is 17.64 N, the motor speed is 15 rev/s and the torque arm radius is 0.15 m. The overall efficiency of the pump is:

a. 0.742
b. 0.648
c. 0.901
d. 0.514
e. None of the above

14) In "comparison of pump characteristic" experiment one of the following statements is correct:

a. For a positive displacement reciprocating pump, the amount of fluid flow rate is independent of pump rotational speed, ω
b. Pumps extract energy from the fluid passing through
c. Pressure of the fluid at the exit of the pump is lower than the pressure of the fluid at the inlet of the pump
d. The performance of the pump is measured using coefficient of performance
e. None of the above

15) In "Liquid-vapor saturation curve" experiment only one statement of the following is correct:

a. Saturation pressure and temperature are independent from each other
b. Saturation pressure is the pressure at which the liquid changes phase into super-heated phase
c. Saturation temperature is the temperature at which the liquid becomes compressed liquid
d. Saturation temperature varies as pressure varies
e. None of the above

Equations sheet:

$Re = \frac{\rho V D}{\mu}$, $\dot{m} = \rho V A$, $K = {}^{\circ}C + 273$, $P_{abs} = P_{gage} + P_{atm}$, $(dT/dP)_{sat} = v_{fg}T/h_{fg}$ $\quad g = 9.81\ m/s^2$

$h_L = h_f + \sum h_m$, $h_m = K\frac{V^2}{2g}$, $h_f = f\frac{L}{D}\frac{V^2}{2g}$ Laminar: $f = \frac{64}{Re}$, Turbulent: $\frac{1}{\sqrt{f}} = -1.8\log\left[\frac{6.9}{Re} + \left(\frac{\epsilon/D}{3.7}\right)^{1.11}\right]$

$\bar{p} = \rho g h_c$, $\quad F = \rho g h_c A$, $\quad y_{cp} = y_c + \frac{I_{xxc}}{y_c A}$, $\quad$ For water: $\rho = 1000\ kg/m^3$

$F = \dot{m}(u_o - u_1\cos\beta)$, $u_o^2 = u^2 - 2gs$ $\quad \dot{m} = \rho u A$ $\quad$ Bernoulli equation: $\frac{P}{\rho g} + \frac{V^2}{2g} + z = constant$

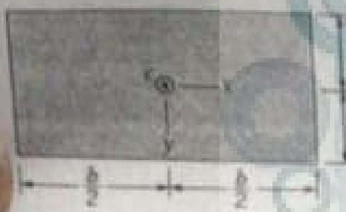
$\dot{Q} = \dot{m}c(T_{out} - T_{in})$, $\dot{Q} = -kA\frac{dT}{dx}$

$\frac{P^*}{P_o} = \left(\frac{2}{\gamma+1}\right)^{\frac{\gamma}{\gamma-1}}$, $v_t = \sqrt{\frac{2\gamma R T_o}{(\gamma-1)}\left[1-\left(\frac{P_t}{P_o}\right)^{\frac{\gamma-1}{\gamma}}\right]}$, $\quad \dot{m}_t = A_t P_o\left(\frac{P_t}{P_o}\right)^{1/\gamma}\sqrt{\frac{2\gamma}{(\gamma-1)RT_o}\left[1-\left(\frac{P_t}{P_o}\right)^{\frac{\gamma-1}{\gamma}}\right]}$, $\gamma = \frac{c_p}{c_v}$

$h_p = \frac{\Delta p}{\rho g} \times 10^5$, $\Delta p = p_d - p_s$, $P_{water} = \rho g \dot{Q} h_p \times 10^{-3}$, $P_{Brake} = 2\pi\omega F R \times 10^{-3}$, $\eta_o = \frac{P_{water}}{P_{Brake}}$, $\eta_v = \frac{\dot{Q}}{\dot{Q}_c}$,

$\dot{Q}_c = \frac{0.75}{12.5} \times 10^{-3}\omega_{pump}$, $\omega_{pump} = 2\omega_m$ and $\dot{m} = \rho\dot{Q}$ $\quad \dot{m}_a = 0.00105\sqrt{\frac{H_1 P_a}{T_a}}$, $\dot{Q}_H - \dot{W}_c - \dot{W}_F = \dot{Q}_L$

$COP_{HP} = \frac{Q_H}{Q_H - Q_L}$, $COP_{HP,rev} = \frac{1}{1 - T_L/T_H}$, $COP_R = \frac{Q_L}{Q_H - Q_L}$, $COP_{R,rev} = \frac{1}{T_H/T_L - 1}$



$A = ba$

$I_{xc} = \frac{1}{12}ba^3$

$I_{yc} = \frac{1}{12}ab^3$

$I_{xyc} = 0$

(a) Rectangle

$A = \pi R^2$

$I_{xc} = I_{yc} = \frac{\pi R^4}{4}$

$I_{xyc} = 0$

(b) Circle

Saturated Water and Steam Tables

Pressure bar	Temperature °C	(v_{fg}) m^3/kg	(h_{fg}) kJ/kg
1	99.60	1.6940	2258
2	120.2	0.8856	2202
3	133.5	0.6057	2164
4	143.6	0.4623	2134
5	151.8	0.3748	2109
6	158.8	0.3156	2087
7	165.0	0.2728	2067
8	170.4	0.2403	2048

(6) Impact of water jet

$\rho = 1000\ kg/m^3$; $\dot{m} = 0.4\ \frac{kg}{s}$; $s = 0.04\ m$; $D_{Nozzle} = 0.01\ m$

→ hemospherical cup

$F_{th} = 2\dot{m}u_o$

$= 2(0.4)(5.0153)$

$= 4.01224\ N$

≈ 4.01 (b)

$\dot{m} = \rho u A_{nozzle}$

$0.4 = (1000)\, u * \frac{\pi}{4}(0.01)^2$

$u = 5.093\ m/s$

$u_o^2 = u^2 - 2gs \Rightarrow u_o = \sqrt{5.093^2 - 2(9.81)(0.04)}$

$* u_o = 5.0153\ m/s$

(7) Flow through Nozzle

(a.)

(8) (c.)

(9) $P_o = 290\ kPa$; $T = 18^\circ C$; $R = 0.287\ \frac{kJ}{kg\,K}$, $\gamma = 1.4$

$A_t = 9.16 \times 10^{-6}\ m^2$, $P_t = 265\ kPa$

$$\dot{m} = A_t P_o \left(\frac{P_t}{P_o}\right)^{\frac{1}{\gamma}} \sqrt{\frac{2\gamma}{(\gamma-1) R T_o}\left(1-\left(\frac{P_t}{P_o}\right)^{\frac{\gamma-1}{\gamma}}\right)}$$

$$= (9.16 \times 10^{-6}) \times 290 \times 10^3 \times \left(\frac{265}{290}\right)^{\frac{1}{1.4}} \times \sqrt{\frac{2(1.4)}{(1.4-1)\,287 \times (18+273)} \times \left(1-\left(\frac{265}{290}\right)^{\frac{1.4-1}{1.4}}\right)}$$

$$= 3.63 \times 10^{-3}\ kg/s$$ (a)

(11) b. convergent – Parallel

4 & 5 : Losses in Pipes

$\dot{m} = 0.2$ kg/s , $\rho = 1000$ kg/m^3 , $D_{small} = 14$ mm , $\mu = 1\times10^{-3}$ $\frac{N.s}{m^2}$

$\varepsilon = 0.0015$ mm

(4) → $Re = \frac{\rho V D_{small}}{\mu} = \frac{1000\left(\frac{\dot{m}}{\rho A}\right) D_{small}}{\mu}$; $A = \frac{\pi}{4} D_{small}^2$, $D_{small} \to 14\times10^{-3}$, $\mu = 1\times10^{-3}$

$Re = 18189.14$, Turbulent flow

(5) $\frac{1}{\sqrt{f}} = -2.0 \log\left(\frac{0.0015\times10^{-3}}{3.7\times14\times10^{-3}} + \frac{2.51}{Re\sqrt{f}}\right)$

$f = 0.027$ (d)

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(6) c

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$\dot{m} = 0.25$ kg/s , $\rho = 1000$ kg/m^3 , $D_{small} = 14$ mm , $\mu = 1\times10^{-3}$ $\frac{N.s}{m^2}$, $h_m = 0.1$ m

$h_m = K\frac{V^2}{2g}$

$0.1 = K\frac{(1.624)^2}{2(9.81)}$

$K = 0.744$ (a)

$\dot{m} = \rho V A$

$0.25 = (1000)\, V \times \frac{\pi}{4}(14\times10^{-3})^2$

$\therefore V = 1.624$ m/s

③ c Thermal Conductivity

⑫ X ⑲ ⓐ

Pump characteristics

Centrifugal pump (13)

$P_s = 0$ bar , $P_d = 0.7$ bar , $\dot{Q} = 3.20 \times 10^{-3} \frac{m^3}{s}$, $\rho = 1000 \frac{kg}{m^3}$

$F = 17.64$ N , $\omega = 15$ rev/s , $R = 0.15$ m

$P_{water}(kW) = \rho g \dot{Q} h_p \times 10^{-3}$

(ρ: $\frac{kg}{m^3}$, g: $\frac{m}{s^2}$, $\dot{Q}$: $\frac{m^3}{s}$, h_p: m)

$h_p = \frac{\Delta P}{\rho g} \times 10^5 = \frac{P_d - P_s}{\rho g} \times 10^5$ (bar)

$= \frac{0.7 \text{ bar}}{(1000)(9.81)} \times 10^5 = 7.135$ m

$P(kW) = (1000)(9.81)(3.2 \times 10^{-3})(7.135) \times 10^{-3}$

$= 0.224$

$P_B(kW) = 2\pi \omega_m F R \times 10^{-3}$

$= 2\pi (15)(17.64)(0.15) \times 10^{-3}$

$= 0.249$

$\eta_o = \frac{P_w}{P_B}$

$= \frac{0.224}{0.249}$

$= 0.899$

≈ 0.901 (c)

(14) (a)

(17) $P_s = 0$ bar , $P_d = 0.4$ bar , $\dot{Q} = 1 \times 10^{-3} \frac{m^3}{s}$, $\rho = 1000$ kg/m³ , $F = 17.64$ N

$\omega = 17.64$ N , $R = 0.15$ m

$Q_c = \left(\frac{0.75}{12.5}\right) \times 10^{-3} \times \omega_{Pump}$, $\omega_p = 2\omega_m$
$= 2(17)$
$= 34 \frac{rev}{s}$

$= \left(\frac{0.75}{12.5}\right) \times 10^{-3} \times 34$

$= 2.04 \times 10^{-3} \frac{m^3}{s}$

$\eta_v = \frac{\dot{Q}_m}{Q_c}$

$= \frac{1 \times 10^{-3}}{2.04 \times 10^{-3}}$

$= 0.49$ (d)

(18) Heat Pump

$\dot{Q}_H = 1.9\ kW,\ \dot{Q}_L = 1.4\ kW,\ T_H = 60\,^\circ C,\ T_L = 7\,^\circ C$

$COP_{(HP)} = \frac{Q_H}{Q_H - Q} = \frac{1.9}{1.9 - 1.4} = \underline{3.8}$ (b)

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(15) Liquid – Vapor

(d)

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(20) $\left(\frac{dT}{dp}\right)_{sat} = \frac{T\, v_{fg}}{h_{fg}}\ [K/kPa]$

$= (133.5 + 273)\,K \cdot \frac{(0.6057)\,m^3}{kg * 2164\,\frac{kJ}{kg}}$ [K / kPa]

$* \left(\frac{dT}{dp}\right)_{sat} = 0.114\ \frac{K}{kPa}$ (a)