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Civil Engineering Hydraulics with worked Examples I. Part 1.

Editor:

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SZÉCHENYI 2020

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INVESTING IN YOUR FUTURE

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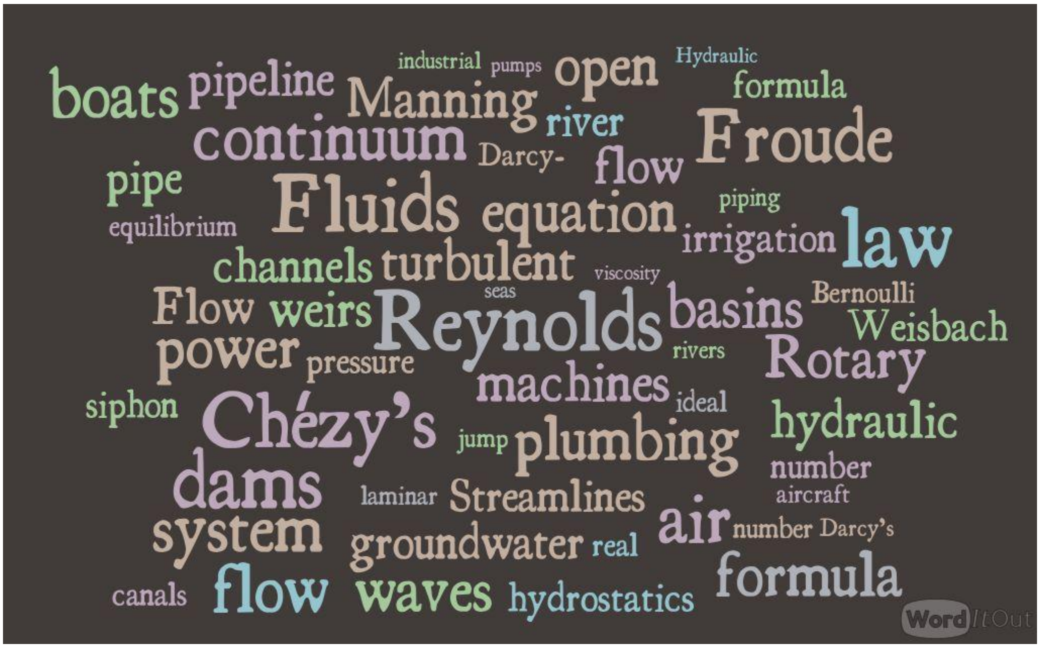


"Water, thou hast no taste, no color, no odor; canst not be defined, art relished while ever mysterious. Not necessary to life, but rather life itself, thou fillest us with a gratification that exceeds the delight of the senses."
Antoine de Saint-Exupéry, Wind, Sand and Stars

1. HISTORY OF HYDRAULICS - SOME CONTRIBUTORS TO THE SCIENCE OF HYDRAULICS - WHO IS WHO?

……………………………………………………………

a) Greek mathematician

b) physicist and astronomer

c) elementary principles of buoyancy and flotation

d) formulation of a hydrostatic principle

e) Archimedes' principle

f) Archimedes screw

……………………………………………………………

a) elementary principle of continuity

b) many basic flow phenomena

c) designs for hydraulic machinery

d) great pioneer of hydraulics

……………………………………………………………

a) barometric height

b) barometer

c) Torricelli's theorem

d) describes the parting speed of a jet of water

e) practical applications in daily life

f) relationship between liquid exit velocity and its height in the container

……………………………………………………………

a) hydraulic press

b) pressure transmissibility

c) Pascal’s law

d) the pressure at a point in a fluid at rest is the same in all directions

……………………………………………………………

a) Philosophiæ Naturalis Principia Mathematica

b) foundations of classical mechanics

c) theoretical predictions

d) Opticks: or, A Treatise of the Reflexions, Refractions, Inflexions and Colours of Light

e) mathematical description of gravity

f) Member of Parliament for the University of Cambridge

g) Royal Society

h) key figure of the scientific revolution

i) laws of motion

……………………………………………………………

a) inventor of the pitot tube

b) French hydraulic engineer

c) flow velocity

d) pitot tube is used to measure the local flow velocity

e) pressure measurement instrument

…………………………………………………………

a) Swiss mathematician and physicist

b) Bernoulli's principle

c) contemporary and close friend of Leonhard Euler

d) metaphysics

e) natural philosophy

f) Fellow of the Royal Society

g) Conservation of Energy

h) worked with Euler on elasticity

i) Bernoulli's method of measuring pressure

j) energy principle to explain velocity-head indication

…………………………………………………………

a) infinitesimal calculus

b) graph theory

c) fluid dynamics

d) Swiss mathematician, physicist, astronomer, engineer

e) Euler's number in calculus

f) Euler equation

g) modulus of elasticity

h) graph theory

i) presented a solution to the problem known as the Seven Bridges of Königsberg

j) First explained role of pressure in fluid flow

…………………………………………………………………

a) French hydraulics engineer

b) Chézy formula

c) open channel flow

d) director of the École nationale des ponts et chaussées

e) his equation can be used to calculate mean flow velocity in conduits

f) predicting flow characteristics

g) Chezy's coefficient

…………………………………………………………………

a) Italian physicist

b) discoverer of the Venturi effect

c) Venturi tube

d) Venturi flow meter

e) Venturi pump

…………………………………………………………………

a) hydraulic engineer

b) theoretical foundation of groundwater hydrology

c) Darcy’s law

d) conducted experiments on pipe flow

e) calculating head loss due to friction

f) unit of measure of fluid permeability

g) Darcy–Weisbach equation

h) filtration and pipe resistance

i) open-channel studies

……………………………………………………………

a) Professor for applied mathematics, mechanics

b) wrote an influential book for mechanical engineering students

c) foreign member of the Royal Swedish Academy of Sciences

d) Incorporated hydraulics

e) nondimensional coefficients

f) resistance equations

……………………………………………………………

a) ship hydrodynamics

b) hydrodynamicist

c) mathematical expertise with practical experimentation

d) Froude's law

e) Froude number in hydrology and fluid mechanics

f) indicate the influence of gravity on fluid motion

g) hydraulic jump

h) rise in water surface elevation

i) Fr is less than 1, small surface waves can move upstream

j) Fr is greater than 1, they will be carried downstream

k) Fr = 1 the critical Froude number), the velocity of flow is equal to the velocity of surface waves

……………………………………………………………

a) Irish hydraulic engineer

b) Manning's coefficient

c) Manning formula for determining open channel flows

d) Handbook of Hydraulics

e) Proposed several formulas for open-channel resistance

……………………………………………………………

a) devised two parameters for viscous flow

b) adapted equations of motion of a viscous fluid

c) prominent Irish innovator in the understanding of fluid dynamics

d) Reynolds number

e) ratio of inertial forces to viscous forces

f) Reynolds' turbulence principles

g) Reynolds stress

h) Reynolds number used for modeling in fluid flow

……………………………………………………………

a) concept of the boundary layer

b) Fluid Flow in Very Little Friction

c) compressibility

d) Prandtl-Glauert correction

……………………………………………………………

a) Moody chart

b) first Professor of Hydraulics in the School of Engineering at Princeton

c) method of correlating pipe resistance data

2. INTRODUCTION TO FLUIDS

Units and Dimensions

QUANTITY	SYMBOL	SI UNIT
Force		$N = kg \cdot m/s^2$
Area	A	
Volume		m^3
Mass	m	
Density	ρ	
Kinematic viscosity		m^2/s
Dynamic viscosity		Pa·s
Pressure	p	
Specific weight	γ	
Temperature		K
Velocity		m/s
Acceleration	a	
Time		s
Energy	E	
Power		J/s = W
Work	W	

2.1. Converting Quantities

27 000 cm = ...dm

30 000 m^2 = ………………………………………………..........cm^2

2750 s = ……………………… min = …………………………h

4.7 km = ……………………………………………………m

3.2 h = ………………………….min = …………………………s

304 km/h = ………………………………………………….m/s

370 K = …………………………………………………… °C

12.5 m/s = ……………………………………………… km/h

3 L = ……………………….. dm^3 = …………………………... m^3

1570 mL = ………………… dL = …………………………….. L

0.25 g / cm^3 = ………………………………………………. kg/m^3

5 mol = ……………………………………………….. number of particles

6300 kJ = ……………………………………………….. J

150 dm^2= ……………………………………………… m^2

94 °C = ………………………………………………… K

35600 m = ……………………………………………...….km

15 cm^3 = …………………………………………………...dm^3

35 N/cm^2= ………………………………………………….Pa

15800 Pa = ……………………………………………….. kPa

740 N/m^2 = ………………………………………… …Pa

4,3 t = …………………………kg =…………………………...…dkg

5200 mg = ……………………………………………… g

3,745 kJ = ………………………………………………….J

35500 kW = ……………………………………………W

4.55 m^3= ………………………………………………….dm^3

13600 kg/m^3 = …………………………………………….. g/cm^3

30 x 10^{23} particles = ………………………………………… mol

5 N/m^3 = ……………………………………………… …N/dm^3

2 m^3/s = ……………………………………………………m^3/h

12770 N = …………………………………………………… kN

15.67 kN/m^3 = ………………………………………………..N/m^3

457.43 m^3= ……………………………………………………cm^3

3 MN/m^2 = ……………………………………………………Pa

10000 cm^2 = …………………………………………………..m^2

23970 mm^3 = …………………………………………………cm^3

2.43 GPa = ……………………………………………………Pa

2.2. What is the definition of the fluid?

A) a substance that doesn't permanently resist distortion
B) has shear stress
C) a substance that does permanently resist distortion
D) shear stress magnitudes depend on the volume of the fluid

2.3. True or false?

1. The principal difference between liquids and gases is in the compressibility
2. Fluids have a preferred shape
3. Gases can fill the container fully
4. Macroscopic properties of gases: pressure, temperature, viscosity, thermal conductivity, volume
5. Gases can be dissolved in the liquid
6. The most obvious property of fluids, their ability to flow and change their volume
7. The most obvious property of gases, their ability to flow and change their shape
8. Gases have a preferred shape
9. The interface forms between the liquid and the surrounding gas called a free surface
10. Gases are compressible
11. The pressure of a gas depends on its temperature
12. The pressure of a gas depends on its volume
13. Incompressible Flow – the volume of the fluid has a constant value throughout the fluid

14. Gas molecules are monatomic, diatomic and polyatomic molecules
15. Gases have mass
16. Fluids have mass
17. Gases diffuse through each other very rapidly
18. The kinetic energy of the gas molecules decreases with added temperature
19. Particles in a liquid are attracted to each other
20. Gases are highly sensitive to changes in temperature and pressure
21. Macroscopic properties of gases: volume, pressure, temperature, mass
22. The density of the fluid can change under pressure
23. In real fluids: shear forces oppose motion of one particle past another
24. An ideal fluid is incompressible, the density is constant

2.4. Comparison liquids and gases - Fill up the missing spots in the table below!

	LIQUID	GAS
TYPES		
PARTICLES		
SHAPE		
EFFECT OF CHANGE OF PRESSURE ON THE VOLUME		
FREE SPACE BETWEEN PARTICLES		
PARTICLES CAN MOVE		
COMPRESSIBILITY		
DISTANCE BETWEEN MOLECULES		
ROLE OF INTERACTIONS OF MOLECULES		
CAUSE OF VISCOSITY		

1) plant oils
2) attraction among molecules
3) large
4) Solutions
5) vibrate, move about, and slide past each other
6) small
7) assumes the shape of the part of the container which it occupies
8) lots of free space between particles
9) significant
10) vibrate and move freely at high speeds
11) compressible
12) small, fill the available space
13) little free space between particles
14) particles can move past one another
15) acetone
16) well separated with no regular arrangement
17) small
18) Sulfur dioxide
19) Suspensions
20) assumes the shape and volume of its container
21) not easily compressible
22) Green House gases
23) Emulsions
24) close together with no regular arrangement
25) particles can move/slide past one another
26) large
27) momentum exchange among molecules
28) Solvents
29) Sea water
30) oxygen

2.5. Gases and their roles in our everyday life - Fill up the missing spots in the table below!

GAS	USES
Natural Gas	A)
Nitrogen	B)
Argon	C)
Chlorine	D)
Sulfur dioxide	E)
Carbon Dioxide	F)
Neon	G)

1. Cooking
2. For oxygen free environment
3. electric bulbs and tubes
4. As sterilizer
5. Wine making
6. Refrigerant
7. electric bulbs and tubes

2.6. True or false?

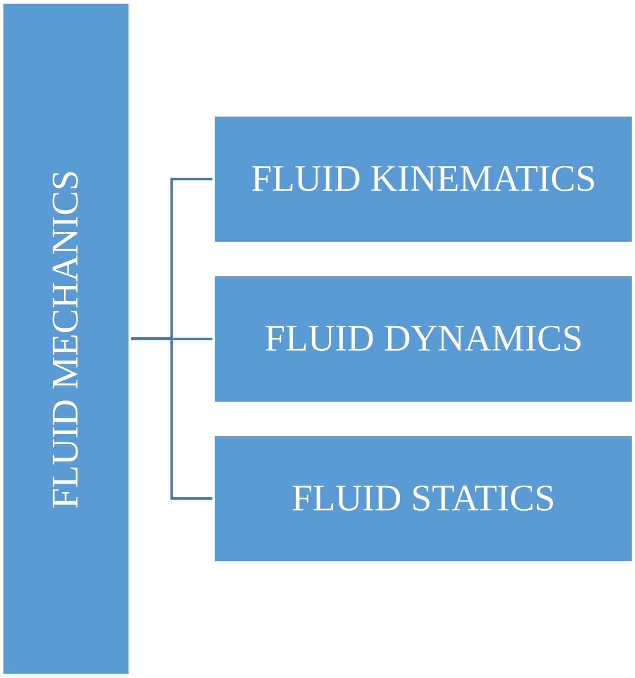
1. If the concentration of the Green House gases increases, it can lead to global warming.
2. Greenhouse gases are from human activities
3. Greenhouse gases aren't Climate Change Indicators
4. Carbon dioxide has a significant impact on global warming partly
5. methane is about 11 times more efficient at absorbing radiation than CO_2

2.7. Ideal Fluid or Real Fluid?

1. Incompressible
2. Viscous in nature
3. Conceptual model of a fluid
4. Compressible
5. Non-Viscous
6. friction between the layers
7. surface tension

8. laminar flow
9. a fluid with no friction
10. Shear forces oppose motion of one particle past another
11. internal molecular activity
12. unable to resist
13. only an imaginary fluid
14. zero viscosity
15. Tangential or shearing forces
16. have a steady – flow
17. turbulent flow
18. no surface tension
19. viscosity
20. constant density

2.8.



1) the study of fluids at rest
2) the study of fluids in motion
3) the study of the effects of forces on fluid motion
4) velocity field
5) characterization of different types of motion
6) Lagrangian description of fluid motion
7) Euler equation of motion
8) description of fluid motion
9) Bernoulli's principle

10) the study of liquid flow
11) a liquid flowing through a pipe
12) Pressure at a point within a fluid
13) calculation of the Hydrostatic Force on a Curved Surface
14) Stability of Immersed and Floating Bodies
15) Mechanical energy of a flowing fluid
16) Flow Over a Weir
17) Hydraulic Jump in an Open Channel Flow
18) fluid forces
19) Hydrostatic Force on a submerged surface
20) Pressure Transmission

3. PROPERTIES OF FLUIDS

3.1. What is the symbol for density?
A) β
B) ρ
C) η
D) σ

3.2. What are units of density?
A) g/cm^3
B) N/m^3
C) kg/m^2
D) kg/m^3

3.3. What is the formula for mass density?
A) density = volume/ mass
B) density = the mass of the substance / unit volume
C) density = the mass of the substance x unit volume
D) density = the mass of the substance + unit volume

3.4. What is the unit of the relative density?
A) g/cm^3
B) N/m^3
C) dimensionless
D) kg/m^3

3.5. If the density of water is 1 gram/cm^3, this means that the mass of 200 cm^3 of water should be
A) 200 grams
B) 1 gram
C) 1000 grams
D) 20 grams

3.6. Convert the density from gram/cubic decimeter [g/dm^3] to kilogram/cubic meter [kg/m^3]!

3.2 g/dm^3 = ……………. kg/m^3

A) 3.2
B) 3200
C) 320 000
D) 0.0032

3.7. Convert the density from kilogram/liter [kg/L] to gram/cubic centimeter [g/cm^3]!

11.22 kg/L = ……………. g/cm^3

A) 0.01122
B) 11.22
C) 11220
D) 11220000

3.8. Convert the density from gram/cubic centimeter [g/cm^3] to kilogram/cubic meter [kg/m^3]!

2.9 g/cm^3 = ……………. kg/m^3

A) 2.9
B) 0.0029
C) 2900
D) 2900000

3.9. Convert the density from kilogram/cubic centimeter [kg/cm^3] to kilogram/cubic meter [kg/m^3]!

0.075 kg/cm^3 = …………… kg/m^3

A) 75000
B) 75
C) 75000000
D) 0.000075

3.10. Convert the density from tonne/cubic meter [t/m^3] to gram/cubic centimeter [g/cm^3]!

4500 t/m^3 = …………… g/cm^3

A) 4500000
B) 4.5
C) 0.0045
D) 4500

3.11. Alcohol is less dense than water. If you measured the mass of the same volume of alcohol and water
a) The mass of the alcohol and water would cancel each other
b) The mass of the alcohol and water would be the same
c) The water would have a lower mass
d) The water would have a greater mass out

3.12. Density of water is maximum at
A) - 4 °C
B) 4 °C
C) 100 °C
D) 0 °C

3.13. The calculation of the specific weight
A) $\gamma=\rho/g$
B) $\gamma=\rho\eta$
C) $\gamma=\rho\nu$
D) $\gamma=\rho g$

3.14. True or falls?
A) Specific gravity usually means relative density with respect to water.
B) The symbol of the relative density is R
C) Relative density is dimensionless
D) Relative density = $\rho_{substance} / \rho_{reference}$
E) Relative density is the specific weight

3.15. How do you convert grams per cubic centimeter to kilograms per cubic meter?

A) divide by 1000
B) multiply by 1000
C) divide by 100
D) multiply by 100

3.16. What is the density of water at 4 degree Celsius?

A) 0.99 g/cm^3
B) 1 g/cm^3
C) 0.85 g/cm^3
D) 0.95 g/cm^3

3.17. Water never has an absolute density. Why?

A) because its density varies with temperature
B) because its density varies with volume
C) because its density varies with pressure
D) because its density varies with viscosity

3.18. True or false?

A) When the temperature changes from either greater or less than 4 degrees, the density will become more then 1 g/cm^3
B) When the temperature changes from either greater or less than 4 degrees, the density will become less then 1 g/cm^3

3.19. Almost ……………… of the Earth's surface is covered with water

A) 90 %
B) 75 %
C) 65 %
D) 55 %

3.20. Water turns to ice from …….. degrees Celsius and below

A) -1
B) 1
C) 0
D) -10

3.21. Water turns into steam from ………… degrees Celsius and above

A) 100.5
B) 100
C) 100.1
D) 100.2

3.22. The density of the Dead Seawater

A) 1.74 kg/litre
B) 1.44 kg/litre
C) 1.24 kg/litre
D) 1.14 kg/litre

3.23. The acidic properties of solution with a pH <7 are due to

A) hydrogen ions
B) oxide ions
C) hydroxide ions
D) hydroxonium ions

3.24. The alkaline properties of solution with a pH >7 are due to

A) oxide ions
B) hydrogen ions
C) hydroxide ions
D) hydroxonium ions

3.25. The most common formula for calculating pH is

A) pH = - $\log_{10}[H^+]$
B) pH = log10 $[H^+]$
C) pH = - $\ln[H^+]$
D) pH = $\ln[H^+]$

3.26. Some common pH values - Fill up the missing spots in the table below!

	pH
Sea Water	
Coffee	
Cola	
Milk	
Hand soap	
Household ammonia	
Pure water	

A) pH = 9.0 -10.0

B) pH = 5.0

C) pH = 11.5

D) pH = 6.6

E) pH = 8.0

F) pH = 7.0

G) pH = 2.5

3.27. True or false?

A) Anthropogenic CO_2 uptake by the ocean increases the pH of seawater
B) Anthropogenic CO_2 uptake by the ocean decreases the pH of seawater

3.28. How can fish survive in the extreme winter the lakes are frozen? Which is the false answer?

A) it's with connection anomalous expansion of water
B) the water under the ice layer remains at 4°C
C) after reaching 4 °C water sinks down
D) as a result close to freezing, warmer water floats to the top and the colder water sinks to the bottom.

3.29. Viscosity is very ……………… dependent.

A) pressure
B) volume
C) mass
D) temperature

3.30. Viscosity of a liquid ………………………………..

A) decreases with increasing temperature
B) decreases with increasing pressure
C) increases with decreasing temperature
D) increases with decreasing pressure

3.31. Viscosity of a gas …………………………………….

A) increases with increasing pressure
B) increases with increasing volume
C) increases with increasing density
D) increases with increasing temperature

3.32. The symbol of the shear stress

A) σ
B) τ
C) Δ
D) s

3.33. The unit of the shear stress

A) N/m
B) Nm
D) N/m^2
D) Nm^2

3.34. Newton's law of viscosity

A) $\tau = \mu \cdot (du / dy)$
B) $\tau = \mu \cdot (du / dt)$
C) $\tau = \mu \cdot (du^2 / dy)$
D) $\tau = \mu \cdot (du / dy2)$

3.35. Water is a ………………………fluid having dynamic viscosity and kinematic viscosity

A) Ideal
B) Newtonian fluids
C) Real Fluids
D) Non- Newtonian Fluids

3.36. True or false? A substance that flows quickly has high viscosity...

A) True
B) False

3.37. Viscosity primarily depends upon

A) pressure
B) density
C) specific weight
D) temperature

3.38. The value of specific weight for water in SI units

A) $9.81 \times 1000 \times 1000\ N/m^3$
B) $9.81 \times 1000\ N/m^3$
C) $9810 \times 1000\ N/m^3$
D) $9810 \times 1000 \times 1000\ N/m^3$

3.39. What is Specific volume?

A) 1 / ρ
B) 1 / V
C) γ/ g
D) η/ g

3.40. True or false? If the specific gravity of a fluid is known, the density of the fluid will be equal to density of water multiplied by the specific gravity of fluid.

A) True
B) False

3.41. When the specific gravity of mercury is 13.6, the density of mercury

A) 13600 x 1000 kg/m^3
B) 13.6 x 1000 x 1000 kg/m^3
C) 13.6 x 1000 kg/m^3
D) 13.6 ÷1000 kg/m^3

3.42. Calculate the specific weight of one litre of a liquid which weight is 8 N.

A) 800 N/m^3
B) 80 N/m^3
C) 8000 N/m^3
D) 80000 N/m^3

3.43. Calculate the density, when the specific gravity is 0.7138!

A) 1.4 kg/m^3
B) 713.8 kg/m^3
C) 71.38 kg/m^3
D) 7.138 kg/m^3

3.44. In SI the unit of viscosity

A) Ns/m
B) $Pa \cdot s^2$
C) $Pa \cdot s$
D) Nm^2/s

3.45. The Greek symbol of the kinematic viscosity
A) σ
B) η
C) χ
D) ν

3.46. In SI the unit of kinematic viscosity
A) m^2/s
B) m/s^2
C) m/s
D) m^2/s^2

3.47. Which is the correct formula?

A) $\eta = \nu \times \rho$
B) $\eta = \nu / \rho$
C) $\eta = \nu \times \gamma$
D) $\eta = \nu / \gamma$

3.48. Which is the correct formula?

A) $\rho = \eta \times \nu$
B) $\rho = \eta / \nu$
C) $\rho = \gamma \times \nu$
D) $\rho = \sigma \times \nu$

3.49. The density of the water is 1000 kg/m^3, the kinematic viscosity is 10^{-6} m^2/s. What is the dynamic viscosity of the water?

A) 10^{-3} Pa·s
B) 10^{-6} Pa·s
C) 10^{-9} Pa·s
D) 10 Pa·s

3.50. True or false? In CGS units, kinematic viscosity is also known stoke.

A) True
B) False

3.51. True or false? One stoke = 1 cm^2/s = 10^{-4} m^2/s

A) True
B) False

3.52. Newton's Law of Viscosity

A) Shear Stress = Viscosity x Shear Rate
B) Shear Stress = Viscosity / Shear Rate
C) Shear Stress = Viscosity x Velocity
D) Shear Stress = Viscosity x Compressibility

3.53. Dynamic viscosity of water at 20 °C

A) 1.0 x 10^{-3} Ns/m^2
B) 1.0 x 10^{-3} m^2/s
C) 1.0 x 10^{-6} Ns/m^2
D) 1.0 x 10^{-6} m^2/s

3.54. Kinematic viscosity of water at 20 °C

A) 1.0 x 10^{-3} m^2/s
B) 1.0 x 10^{-6} m^2/s
C) 1.0 x 10^{-3} N/m^2
D) 1.0 x 10^{-6} N/m^2

3.55. True or false?

A) Adhesion is the property of same molecules or surfaces to cling to each other
B) Cohesion is the property of like molecules
C) Cohesive forces are responsible for surface tension
D) Adhesion is the property of different molecules or surfaces to cling to each other

3.56. Cohesive Forces

A) Attractive forces between molecules of the same type
B) Attractive forces between atoms of the same type
C) Attractive forces between molecules of different types
D) Attractive forces between atoms of different types

3.57. Adhesive Forces

A) Attractive forces between molecules of the same type
B) Attractive forces between atoms of the same type
C) Attractive forces between molecules of different types
D) Attractive forces between atoms of different types

3.58. The symbol of the surface tension

A) ρ
B) σ
C) χ
D) ν

3.59. The unit of the surface tension

A) N/m
B) Nm
C) N/m^2
D) kPa

3.60. How can we calculate the capillary rise or depression?

A) $h = (2 \cdot \sigma \cdot \cos \Theta) / (\rho \cdot g \cdot d)$
B) $h = (4 \cdot \sigma \cdot \cos \Theta) / (\rho \cdot g \cdot d^2)$
C) $h = (4 \cdot \sigma \cdot \cos \Theta) / (\rho \cdot g \cdot d)$
D) $h = (2 \cdot \sigma \cdot \cos \Theta) / (\rho \cdot g \cdot d^2)$

3.61. Calculate the gauge pressure inside a soap bubble 2.25×10^{-4} m in radius using the surface tension for soapy water ($\gamma = 0.0370$ N/m).

Solution:

$P = (4\gamma) / r$

$\gamma = 0.0370$ N/m

$r = 2.25 \times 10^{-4}$ m

$P = (4 \times 0.0370) / (2.25 \times 10^{-4}) = 657.778\ N/m^2 = 657.778$ Pa

3.62. Calculate the gauge pressures inside 2.00-cm-radius bubbles of water at 20 °C. The surface tension of the water is 0.0728 N/m.

Solution:

$P = (4\gamma) / r$

$\gamma = 0.0728$ N/m

$r = 0.02$ m

$P = (4 \times 0.0728) / 0.02 = 14.56\ N/m^2$

3.63. Which is the correct definition?

A) The surface tension is the adhesive forces between molecules which cause the surface of a liquid to contract to the smallest possible surface area.

B) The surface tension is the cohesive forces between molecules which cause the surface of a liquid to contract to the biggest possible surface area.

C) The surface tension is the adhesive forces between molecules which cause the surface of a liquid to contract to the biggest possible surface area.

D) The surface tension is the cohesive forces between molecules which cause the surface of a liquid to contract to the smallest possible surface area.

3.64. What are h, y, Θ, ρand r in the the equation of capillary action?

$h = [(2\gamma\cos\Theta) / (\rho g r)]$

h ………………………………………………………..
γ …………………………………………………………
Θ ………………………………………………………..
r ………………………………………………………..

3.65. Tree hydraulics: how sap rises. Which equation can we use by the calculation?

A) Newton's law
B) Pascal's law
C) Hagen–Poiseuille equation
D) Darcy's law

3.66. At 10°C what diameter glass tube is necessary to keep the capillary-height change of water less than 4 mm?

Surface tension of water at 10 C: $\sigma = 0.0742$ N/m

$\Theta=0$ $\rho= 1000\ \text{kg/m}^3$

Solution:

$h = [(2\sigma\cos\Theta) /(\rho g r)]$

$0.004 = [(2 \cdot 0.0742 \cdot \cos 0) / (1000 \cdot 9.81 \cdot r)]$

r= 0.00378 m = 3.78 mm

d= 2 x r = 2 x 3.78 = 7.56 mm (or greater)

3.67. What capillary depression of mercury (Θ=120°) may be expected in a 0.004 m diameter tube at 20°C?

σ = 0.514 N/m

ρ= 13570 kg/m^3

r = d/2 = 0.004 / 2 = 0.002 m

Solution:

$h = [(2 \cdot \sigma \cdot \cos\Theta) / (\rho g r)]$

$h = [(2 \cdot 0.514 \cdot \cos 120) / (13570 \cdot 9.81 \cdot 0.002) = -0.0019$ m

3.68. Calculate the capillary rise in the tube for a water – air – glass interface (Θ = 0°) if the tube radius is 2 mm and the temperature is 30 °C.

σ = 0.0712 N/m

ρ= 996 kg/m^3

r = 0.002 m

Solution:

$h = [(2 \cdot \sigma \cdot \cos\Theta) / (\rho g r)]$

$h = [(2 \cdot 0.0712 \cdot \cos 0) / (996 \cdot 9.81 \cdot 0.002) = 0.00728$ m = 7.28 mm

3.69. What are h; $r^2\pi$; ρ in the formula of the downward force?

Downward force = $r^2\pi\ \rho\ g\ h$

h …………………………………………………………………….

$r^2\pi$ ……………………………………………………………………

ρ………………………………………………………………………

3.70. What are σ; 2rπ ; cosα in the formula of the upward force?

Upward force = 2 r π σ cos α

σ ……………………………………………………………………………..
2rπ …………………………………………………………………………
cosα…………………………………………………………………….

3.71. Distilled water at 10 °C stands in a glass tube of 7.5 mm diameter at a height of 27.0 mm. What is the true static height?

d = 7.5 mm
r = d / 2 = 7.5 / 2 = 3.75 mm = 0.00375 m
Θ = 0°
σ = 0.0742 N/m
ρ= 1000 kg/m^3

Solution:

h = [(2 · σ · cosΘ) / (ρgr)]
h= [(2· 0.0742 · cos0) / (1000 · 9.81 · 0.00375) = 0.00403 m = 4.03 mm

True static height = 27.0 – 4.03 = 22.97 mm

3.72. True or false?

Capillary water is the soil moisture located within the interstices and voids of capillary forces

A) True
B) False

3.73. True or false?

Since the soil pores always carry adsorbed water, the meniscus formation in capillary tube will always be convex.

A) True
B) False

3.74. A narrow capillary glass tube of radius 1.1 mm is dipped in mercury whose angle of contact with glass is 120 degree. Calculate the capillary depression of mercury in the tube. Surface tension of mercury is 0.465 N/m, and the density of the mercury is 13600 kg/m^3.

Solution:

$h = [(2 \cdot \sigma \cdot \cos \Theta) / (r \cdot \rho \cdot g)]$

$r = 1.5$ mm $= 0.0011$ m
$\Theta = 135°$
$\sigma = 0.465$ N/m
$\rho = 13600$ kg/m^3

$h = [(2 \cdot 0.465 \cdot \cos 135) / (0.0011 \cdot 13600 \cdot 9.81)]$

$h = [-0.657) / (146.757)]$

$h = - 0.00447$ m $= - 4.47$ mm

3.75. True or false?

Capillary rise

A) Adhesion > Cohesion
B) Adhesion < Cohesion

3.76. True or false?

Capillary depression

A) Adhesion > Cohesion
B) Adhesion < Cohesion

3.77. A fluid, which is incompressible and is having no viscosity, is known as…

A) a Real Fluid
B) a Non- Newtonian Fluid
C) an Ideal Plastic Fluid
D) an Ideal Fluid

3.78. A fluid, which possesses viscosity, in known as…

A) a Real Fluid
B) a Non- Newtonian Fluid
C) an Ideal Plastic Fluid
D) an Ideal Fluid

3.79. Water, air, alcohol, glycerol, and thin motor oil are all examples of ……………………. over the range of shear stresses and shear rates encountered in everyday life

A) Ideal fluids
B) Newtonian fluids
C) Real Fluids
D) Non- Newtonian Fluids

3.80. An ideal fluid isn't ….

A) Incompressible
B) Irrotational
C) Nonviscous
D) Steady flow
E) Compressible

3.81. Real fluid

A) incompressible
B) fluid with no friction
C) zero viscosity
D) fluid friction is created

3.82. True or false? Compressibility =The property that allows a fluid to be compressed into a smaller volume.

A) True
B) False

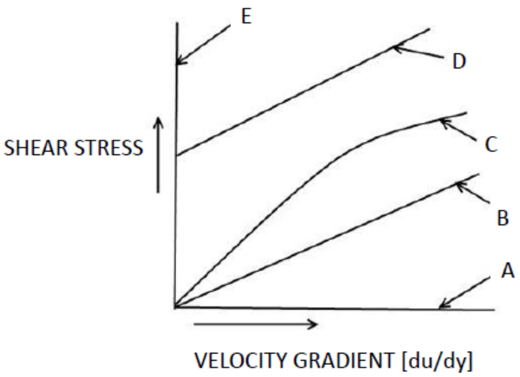
3.83. True or false? The ideal fluid is inviscid (it's viscosity is zero).

A) True
B) False

3.84. A fluid has viscosity, surface tension and it is compressible is called as….

A) Ideal fluid
B) Real fluid
C) Ideal Plastic Fluid
D) Non- Newtonian Fluid

3.85. Types of fluids



1. Ideal solid
2. Ideal plastic fluid
3. Non Newtonian fluid
4. Newtonian fluid
5. Ideal fluid

3.86. Ideal Fluids or Real Fluids?

A) Ideal Fluids
B) Real Fluids

1. Particles are constantly interacting
2. Viscosity
3. No friction
4. Shear forces oppose motion of one particle past another
5. Incompressible
6. Fluid friction
7. Inviscid
8. Theoretical
9. Isochoric flow
10. Zero viscosity

3.87. True or false?

A) All the fluids in reality have viscosity
B) The non-Newtonian fluids are classified as pseudo-plastic, dilatant and Bingham plastic
C) A hypothetical fluid having a zero viscosity
D) Liquids: viscosity increases as temperature increases
E) Motor oil has low viscosity
F) Gases: viscosity increases as temperature decreases
G) μ = coefficient of viscosity = absolute viscosity = dynamic viscosity
H) when liquids follow linear relation of $\tau = \mu \cdot (du / dy)$ are called Newtonian fluids
I) Viscosity is a measure of the resistance of a fluid
J) All real fluids have some resistance to stress
K) Newtonian fluids have a constant viscosity
L) water is Newtonian fluid
M) Shear thickening means: viscosity decreases with the rate of shear
N) Newton's law of viscosity is a fundamental law of nature
O) Viscosity is measured with various types of viscometers
P) The reciprocal of viscosity is the fluidity
Q) a fluid which has no resistance to shear stress is known as a real fluid
R) a fluid which has no resistance to shear stress is known as an ideal fluid
S) the symbol of the shear stress is: τ
T) shear velocity can be written [du/dy]
U) symbol for dynamic viscosity is the Greek letter mu (μ)
V) The symbol η is used for dynamic viscosity
W) SI unit of dynamic viscosity is the pascal-second (Pa·s)
X) [Pa·s] is equivalent to [N·s/m]
Y) kinematic viscosity is defined as $\gamma \cdot \rho$

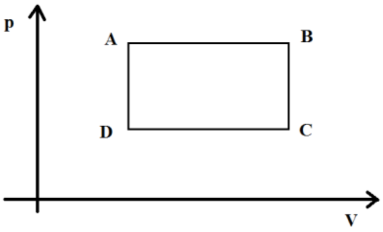
3.88. If the changes in density occurs at constant temperature, then the process is called

A) adiabatic
B) isothermal
C) isobaric
D) isochoric

3.89. In isochoric process ……….is constant during process

A) pressure
B) temperature
C) volume
D) heat transfer

3.90. Consider the cycle in the diagram made of 2 isobaric process. What are these?



A) AB and DC
B) AD and DC
C) BC and CD
D) AD and BC

3.91. Which one of the following is the extensive property of a thermodynamic system?

A) Pressure
B) Volume
C) Density
D) Temperature

3.92. An isobaric process is a thermodynamic process in which the …………………. remains constant

A) volume
B) pressure
C) temperature
D) mass

3.93. In an isobaric process, there are typically ……………energy changes

A) external
B) internal

3.94. The work at a constant pressure can be calculated with [W = p x Δ V].
ΔV is positive, if ……………

A) the system contracts
B) the system does positive work
C) the system expands
D) the system does negative work

3.95. The work at a constant pressure can be calculated with [W= p x Δ V]. ΔV is negative, if …………………………….

A) the system contracts
B) the system does positive work
C) the system expands
D) the system does negative work

3.96. The First Law of Thermodynamics can be written: $U_2 - U_1 = \Delta U = Q - W$
We can use uniform conventions for representing the quantities.

U_1:…………………………………………………………………………………
…………………………………………………………………………………….

U_2:…………………………………………………………………………………
……………………………………………………………………………………..

$\Delta U = U_2 - U_1$
………………………………………………………………………………………
…..

Q:………………………………………………………………………………….
…………………………………………………………………………………….

W:………………………………………………………………………………….
…………………………………………………………………………………….

3.97. In a phase diagram, an ……………………………process would show up as a horizontal line.

A) isochoric
B) isobaric
C) adiabatic
D) isothermal

3.98. Adiabatic process

A) no change in volume
B) no change in temperature
C) no change in pressure
D) no heat transfer into or out of the system

3.99. Isochoric process

A) no change in temperature
B) no change in volume
C) no change in pressure
D) the system does no work

3.100. Isothermal process

A) no change in volume
B) no change in temperature
C) no change in pressure
D) no heat transfer into or out of the system

3.101. Isobaric process

A) no change in temperature
B) no change in volume
C) no change in pressure
D) the system does no work

3.102. Fill up the missing spots in the table below!

ISOCHORIC	V = constant	A)…………………… ………………………… B)…………………… …………………………	$\Delta U = Q$
ISOBARIC	C)…………… ………………	D)…………………… …………………………	
ISOTHERMAL	T = constant	E)…………………… ………………………	F)………………… ………………………
ADIABATIC	no heat transfer	G)…………………… ………………………	H)………………… ………………………

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3.103. Pressure law

A) V / T = constant

B) $p \cdot V$ = constant

C) p / T = constant

D) $(p \cdot V) / T = n \cdot R$

3.104. Charles' law

A) V / T = constant

B) $p \cdot V$ = constant

C) p / T = constant

D) $(p \cdot V) / T = n \cdot R$

3.105. The ideal gas equation

A) V / T = constant

B) $(p \cdot V) / T = n \cdot R$

C) $p \cdot V$ = constant

D) p / T = constant

3.106. Boyle's law

A) p / T = constant

B) V / T = constant

C) $(p \cdot V) / T = n \cdot R$

D) $p \cdot V$ = constant

3.107. True or false? Ideal gases……

A) collisions aren't elastic

B) There are no intermolecular forces

C) Molecules are in rapid motion

D) The total volume of the molecules isn't negligible compared to the volume of the container

3.108. Fill up the missing spots in the table below!

BOYLE'S LAW A)…………………………… …………………………………	p x V = constant	B)…………………… ……………………… fixed T, n
C)…………………………… 1787	D)………………… ……………………..	$V_1 / V_2 = T_1 / T_2$ E)…………………… ………………………..
AVOGADRO F)……………………………	G)………………… ……………………..	fixed p, T

fixed p, n V / n = constant 1662 Charles' Law

$p_1 \times V_1 = p_2 \times V_2$ V / T = constant 1811

3.109. A gas at 24 °C and 0.27 MPa abs has a volume of 45 L and a gas constant (R) of 220 m·N/(kg·K). Determine the density and mass of the gas.

Solution:

$\rho = p/RT = 0.27 \times 10^6 / [(220) \times (24+273)] = 4.13\ kg/m^3$

$m = \rho \times V = 4.13 \times 0.045 = 0.186\ kg$

3.110. One kilogram of hydrogen is confined in a volume of 220 dm^3 at -55 °C. What is the pressure if R is 4.115 kJ/kg·K?

Solution:

$p = \rho \times R \times T$

$\rho = m/V = 1/0.220 = 4.54$ kg /m^3

R = 4.115 kJ/kg·K = 4115 J/kg ·K

T= -55 + 273 = 218 K

$p = 4.54 \times 4115 \times 218 = 4.073 \times 10^6$ Pa

3.111. In all gas equations, temperature is measured in

A) Celsius
B) Fahrenheit
C) Kelvin
D) It doesn't matter

3.112. In the ideal gas law, which variable represents the gas constant?

A) n
B) R
C) V
D) T

3.113. What about gasses can be measured?

A) Temperature, Volume, and Pressure
B) Volume and Temperature
C) Pressure and Volume
D) Pressure, Temperature, Volume, and Moles

3.114. As number of moles goes up, volume

A) goes up
B) goes down
C) stays the same

3.115. Fill up the table below with commonly used units for the temperature, pressure, and volume of gas!

Physical quantities	Units
Temperature	
Pressure	
Volume	

None:

……………………… ………………………
……………………… ……………………..
…………………….. ……………………..

bar
Bq
°C
m^3
°F
Pa
mmHg
cm^3
Hz
K
J
torr
m/s
atm
lx
kPa
Sv

3.116. Pressure Units - Fill up the missing spots in the table below!

Unit	Symbol	Equivalent to 1 atm
Bar	bar	
Torr	Torr	
Millimeter of Mercury	mmHg	
Pascal	Pa	
Kilopascal	kPa	

3.117. The SI unit for pressure

A) bar
B) kPa
C) atm
D) Pa

3.118. What is the unit of force?

A) Joule
B) Newton
C) Watt
D) Kelvin

3.119. What would be the weight of a 5 kg mass on a planet where the acceleration due to gravity is 9.81 m/s^2?

m = 5 kg
a= 9.81 m/s2
W = F = m x a = 5 x 9.81 = 49.05 N

3.120. A 4 kg object is given a net force of 24 N. What acceleration does the object have?

A) 6 m/s
B) 6 m/s2
C) 0.166 m/s2
D) 28 m/s2

3.121. What is the mass of an object if a 30 N force gives an acceleration of 5 m/s^2?

A) 150 kg
B) 0.6 kg
C) 6 kg
D) 6000 kg

3.122. The SI unit for the gas constant

A) 8.3145 m^3 Pa mol^{-1} K^{-1}
B) 0.082057 L atm mol^{-1} K^{-1}
C) 62.364 L Torr mol^{-1} K^{-1}
D) 8.3145 J mol^{-1} K^{-1}

3.123. What Is The Formula For Boyle's Law?

A) $p_i \times V_i = p_f \times V_f$
B) p x V = zero
C) p/V = const
D) p/T = const

3.124. In the Boyle's Law Formula V_i is the

A) initial pressure
B) initial volume
C) final pressure
D) final volume

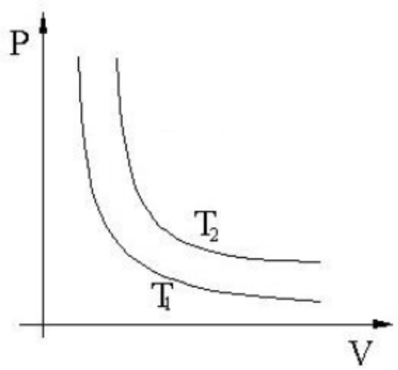
3.125. In the Boyle's Law Formula p_f is the

A) initial pressure
B) initial volume
C) final pressure
D) final volume

3.126. True or false? Boyle's Law means: the volume of a mass of gas is inversely proportional to its pressure.

A) True
B) False

3.127. What is the correct option?



A) $T_1 = T_2$
B) $T_1 > T_2$
C) $T_1 < T_2$

3.128. If 22.5 dm^3 of nitrogen at 758 Hgmm are compressed to
737 Hgmm at constant temperature. What is the new volume in m^3?

Solution:

$p_1 \times V_1 = p_2 \times V_2$

$V_2 = (p_1 \times V_1) / p_2$

$V_1 = 22.5 / 1000 = 0.0225\ m^3$

1 [mmHg] = 133.3224 [Pa]

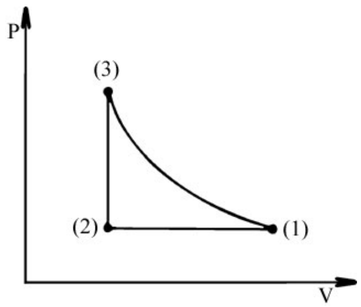
p_1= 758 Hgmm = 101058,38 Pa
p_2 = 737 Hgmm = 98258,61 Pa
V_2= (101058,38 x 0.0225) / 98258,61 = 0.023 m^3

3.129. 2000 cm^3 of a gas at standard temperature and pressure is compressed to 1473 mL. What is the new pressure of the gas?

Solution:

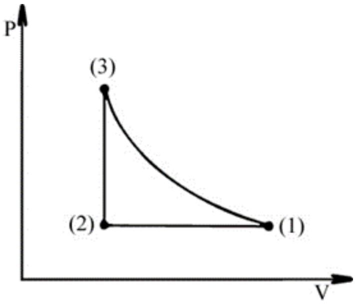
p_1 = 1 atm
V_1 = 2000 cm^3 = 2 dm^3 = 0.002 m^3
V_2 = 1473 mL = 1.473 dm^3 = 0.001473 m^3
p_2 = ?
$p_1 \times V_1 = p_2 \times V_2$
$p_2 = [p_1 \times V_1] / V_2$
p_2 = [1 x 0.002] / 0.001473 = 1.358 atm

3.130. What is isobaric process in the diagram?



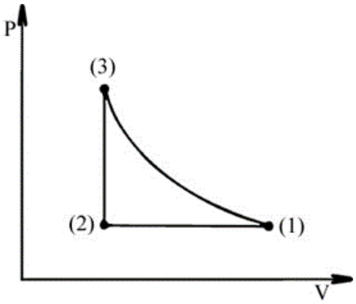
A) (3) → (1)
B) (2) → (3)
C) (1) → (3)
D) (1) → (2)

3.131. What is isothermal process in the diagram?



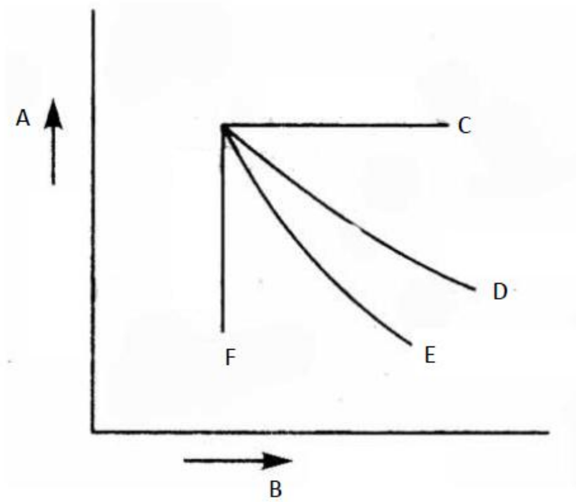
A) (3) → (1)
B) (2) → (3)
C) (2) → (1)
D) (1) → (2)

3.132. What is isochoric process in the diagram?



A) (3) → (1)
B) (2) → (3)
C) (2) → (1)
D) (1) → (2)

3.133. What do these letters spell?



1. Isobaric
2. Isothermal
3. Volume
4. Isochoric
5. Adiabatic
6. Pressure

3.134. The symbol of the gas constant

A) k
B) R
C) f
D) n

3.135. The units of the gas constant

A) bar/K
B) Pa/K
C) J/mol·K
D) cal/mol

3.136. The symbol of the Boltzmann constant

A) B
B) z
C) c
D) k

3.137. Which is the correct answer?

A) $k = 8.31\ J / K^{-1}$
B) $k = 1.3806 \times 10^{-23}\ J \cdot K^{-1}$
C) $k = 6 \times 10^{23}$
D) $k = 1.3806 \times 10^{-26}\ J \cdot K^{-1}$

3.138. R is related to the Boltzmann constant (k) by

A) $R = m/M \cdot k \cdot N_A$
B) $R = n \cdot k \cdot N_A$
C) $R = k \cdot N_A$
D) $R = N_A / k$

3.139. True or false?

A) R the molar gas constant, is the gas constant for one mole of gas

B) $p \times V = N \times R \times T$

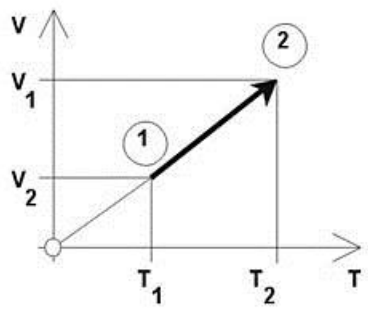
C) k is the gas constant for one particle of gas

D) $k = N_A / R$

E) $k = 1.38 \times 10^{-23}$ J/K

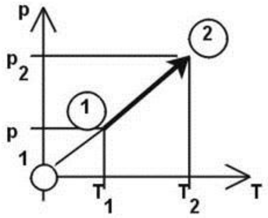
F) $p \times V = N \times k \times T$

3.140. The process is….



A) Isobaric
B) Adiabatic
C) Isothermal
D) Isochoric

3.141. The process is….



A) Isobaric
B) Adiabatic
C) Isothermal
D) Isochoric

3.142. Fill up the missing spots in the table below!

Type of Gas Law	Formula	Description
1.	2. $p_1 \times V_1 = p_2 \times V_2$	3.
4.	5.	6.
7.	8.	9.
10. Charles' Law	11.	12.
13.	14. $pV = nRT$	

A) $V_1 / T_1 = V_2 / T_2$
B) Combined Law
C) $p_1 / T_1 = p_2 / T_2$
D) Obtained by combining Boyle's Law, Charles' Law and Gay-Lussac's Law
E) Boyle's Law
F) At constant P, as volume increases, temperature increases
G) $(p_1 \times V_1) / T_1 = (p_2 \times V_2) / T_2$
H) At constant T, as pressure increases, volume decreases
I) Gay - Lussac's Law
J) At constant V, as pressure increases, temperature increases

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3.143. Air is kept at a pressure of 300 kPa and a temperature of 290 K in a 380000 cm^3 container. What is the mass of the air? The gas constant of air is: R = 287 J/kg x K

Solution:

p = 300 kPa = 300 000 Pa
T = 290 K
V= 380 000 cm^3 = 380 dm^3 = 0.380 m^3

$\rho = p/RT = 300000 / (287 \times 290) = 3.604\ kg / m^3$

$m = \rho \times V = 3.604 \times 0.380 = 1.369\ kg$

3.144. For a certain amount (n = constant) of gas in a closed system, how does volume V vary with the temperature? In the following, k is a constant depending on n and P.

A) V = k T
B) T V = k
C) V = k
D) V = k / T

3.145. Boyles law is PV = constant. A sketch of P vs V on graph paper is similar to a sketch of the equation xy = 5. What curve(s) does this equation represent?

A) an ellipse
B) a pair of hyperbola
C) a parabola
D) a hyperbola

3.146. Boyle's law: When…….. is held constant, the pressure and volume of a gas are ………………………proportional

A) temperature, equally
B) temperature, inversely
C) mass, equally
D) mass, inversely

3.147. A gas at a volume of 4 liters is at a pressure of 2 atm. The volume is changed to 16 Liters, what must the new pressure be?

A) 0.5 atm
B) 8 atm
C) 4 atm
D) 0.75 atm

3.148. In the gas laboratory is an air compressor. The tank of the leaky air compressor originally holds 100 dm^3 of air at 28 °C and 207 kPa. During a compression process, 3 grams of air is lost, the remaining air occupies 47 L at 490 kPa. What is the temperature of the remaining air?

Solution:

p_1 = 207 kPa = 207000 Pa
R = 287 J/ kg x K
T_1 = 28 °C = 28 + 273 = 301 K
V_1= 100 dm^3 = 0.1 m^3
p_2 = 490 kPa = 490000 Pa
V_2 = 47 L = 0.047 m^3

$\rho_1 = p_1 / RT_1 = 207000 / (287 \times 301) = 2.396\ kg/m^3$

$m_1 = \rho_1 \times V_1 = 2.396 \times 0.1 = 0.2396\ kg$

$\rho_2 = p_2 / RT_2$

$\rho_2 = m_2 / V_2 = [0.2396 – 0.003] / 0.047 = 5.034\ kg/m^3$

$5.034 = 490000 / [287 \times T_2]$
$1444.758\ T_2 = 490000$
$T_2 = 339.16\ K$

3.149. A rigid container of O_2 has a pressure 3.7 atm at a temperature of 724 K. What is the pressure at 1526 K? (C)

A) 7.4 atm
B) 0.47 atm
C) 7.79 atm
D) 2.1 atm

Solution:

$p_2 = [p_1 \times T_2] / T_1$

p_1 = 3.7 atm
T_1 = 724 K
T_2 = 1526 K

P_2 = ?

$p_2 = [3.7 \times 1526] / 724 = 7.79\ atm$

3.150. Matching

1. Partial pressure
2. Combined Gas Law
3. Boyle’s Law
4. Ideal Gas Constant
5. Charles’ Law
6. Ideal Gas Law

A) The combined gas law argues about the Boyle's law, Charles's law and Gay-Lussac's law

B) 8.3145 m^3 Pa mol^{-1} K^{-1}

C) The contribution each gas in a mixture makes to the total pressure

D) Is a statement of the relationship between the pressure and volume of gasses

E) The volume of a fixed mass of gas is directly proportional to its Kelvin temperature if the pressure is constant

F) An ideal gas can be characterized by three state variables: absolute pressure (P), volume (V), and absolute temperature (T). The relationship between them: PV = nRT = NkT

3.151. True or false?

1. Diffusion: The tendency of molecules to move toward areas of higher concentration until the concentration is uniform throughout.

2. Ideal Gas Constant: A term in the ideal gas law, which has the value 8.31 J/molK

3. The volume occupied by one mole, n = 1, of substance is called the molar volume,
   Vmolar = V / n.

4. P V = n R T, is called the ideal gas law or equation of state

5. Boyle’s Law: states that for a given mass of gas at constant temperature, the volume of the gas varies inversely with volume

6. Gay-Lussac’s Law: The pressure of a gas is directly proportional to the Kelvin temperature if the volume remains constant

7. compressibility: measure of how much the volume of matter decreases under pressure

8. Relationship between the volume (V) and the pressure (p) of a contained gas at constant temperature (T): when the pressure decreases, volume increases

9. Charles' Law describes the proportional relationship between the pressure and volume of a gas

10. Dalton's law of partial pressures states that the volume of a gas is directly proportional to its temperature in kelvins if the pressure and the number of particles is constant.

11. Gay-Lussac's law: volume is dierectly proportional to temperature at constant pressure

3.152. Gas Laws - Fill up the missing spots in the table below!

Name of the Gas Law	Equation	Parameters that change	Parameters held constant
Boyles	$p_1 \times V_1 = p_2 \times V_2$	1.	2.
Gay-Lussac	3.	4.	V amount of gas
Charles	5.	V, T	6.
Combined	7.	8.	amount of gas

A) $p_1 \times T_2 = p_2 \times T_1$
B) p, V, T
C) p, V
D) $V_1 \times T_2 = V_2 \times T_1$
E) p, T
F) $p_1 \times V_1 \times T_2 = p_2 \times V_2 \times T_1$
G) T amount of gas
H) p amount of gas

3.153. Calculate the density, the specific weight and the volume of chloride gas at 27°C and pressure of 750 000 N/m^2.

T = 27 + 273 = 300 K

R = 118 J / mol K

p = 750 000 N/m^2

Solution:

$\rho = p / R \cdot T$

$\rho = 750000 / (118 \times 300) = 21.186$ kg/m^3

$\gamma = \rho \times g = 21.186 \times 9.81 = 207.83$ N/m^3

$V = 1 / \rho = 1 / 21.186 = 0.0472$ m^3 / kg

3.154. A reservoir of glycerin has a mass of 1500 kg and a volume of 1189.5 dm^3. Find a) the gycerin's weight (W), b) the mass density (ρ), and c) the specific weight (γ).

Solution:

m = 1500 kg
V = 1189.5 dm^3 = 1.1895 m^3

a) F=W=m x a = 1500 x 9.81 = 14715 N
b) ρ= m/V = 1500 / 1.1895 = 1261.03 kg/m^3
c) γ= W/V = 14715 / 1.1895 = 1237.07 N/m^3 or γ= ρ x g = 1261.03 x 9.81 = 1237.07 N/m^3

3.155. If the weight of a substance is 9.7 kN/m^3, what is its mass density?

A) 0.988 kg/m^3
B) 988.78 kg/m^3
C) 0.988 g/cm^3
D) 988.78 g/cm^3

3.156. If V_1 = 8.33 L, P_1 = 1.82 atm, and T_1 = 286 K, V_2 = 5.72 L and T_2 = 355 K what is p_2?

A) 409 torr
B) 32.2 atm
C) 3.22 atm
D) 662 torr

3.157. The symbol of the Bulk modulus

A) K
B) C
C) b
D) BM

3.158. What is the SI unit of the Bulk modulus elasticity?

A) Pa or N/m^2
B) Nm
C) kPa
D) psi

3.159. True or false?

The Bulk Modulus Elasticity is a special material property characterizing the compressibility of a fluid.

3.160. The Bulk Modulus Elasticity can be calculated as

$K = - dp / (dV / V_0) = - (p_1 - p_0) / [(V_1 - V_0) / V_0]$

K=………………………………………………………………………………………

dp=……………………………………………………………………………………..

dV=……………………………………………………………………………………..

V_0=……………………………………………………………………………………..

p_0=……………………………………………………………………………………...

p_1=……………………………………………………………………………………..

V_1=……………………………………………………………………………………..

3.161. Which is the correct formula?

A) $K= -\Delta p/(\Delta V/V)$
B) $K= \Delta p/(\Delta V/V)$
C) $K= -\Delta p/(V/\Delta V)$
D) $K= \Delta p/(V/\Delta V)$

3.162. A liquid compressed in a cylinder has a volume of 1200 cm^3 at 2 MN/m^2 and a volume of 0.887 dm^3at 3 MN/m^2. What is its bulk modulus of elasticity (K)?

A) 3846 Pa
B) 3.846 MPa
C) - 3.846 MPa
D) 1.001 MPa

Solution

$K= -\Delta p/(\Delta V/V)$
$K= - 1 / [(887-1200)/1200 = 3.846$ MPa

3.163. The symbol of the Surface Tension

A)∑
B) σ
C) χ
D) τ

3.164. The surface tension of water in contact with air at 20 °C is 0.0725 N/m. The pressure inside a droplet of water is to be 0.04 N/cm^2 greater than the outside pressure. Calculate the diameter of the droplet of water.

A) 1.45 mm
B) 1.44 mm
C) 2.9 mm
D) 0.725 mm

Solution:

$\sigma= 0.0725$ N/m
$p= 0.04\ N/cm^2= 0.04 \times 10^4 N/m^2$

$p= (4\sigma) / d$

$0.04 \times 10^{4} = (4 \times 0.0725) /d$
$d = 0.000725$ m = 0.725 mm

3.165. True or false?

Compressibility is the reciprocal of bulk modulus of elasticity.

A) True
B) False

3.166. True or false?

Poise and stokes are the units of viscosity and kinematic viscosity respectively.

A) True
B) False

3.167. How to Convert Celsius to Kelvin?

A) T(K) = T(°C) - 273.15
B) T(K) = T(°C) x 273.15
C) T(K) = T(°C) + 273.15
D) T(K) = T(°C) ÷ 273.15

3.168. How to Convert Kelvin to Celsius?

A) T(°C) = T(K) - 273.15
B) T(°C) = T(K) - 273
C) T(°C) = T(K) + 273.15
D) T(°C) = T(K) + 273

3.169. What are extensive properties in thermodynamics?

A) density, mass, length
B) mass, volume, length
C) boiling point, mass, density
D) mass, volume, shape

3.170. The mass is 600 g and the volume is 200 cm3. Determine the specific volume!

A) 3 g/cm^3
B) 0.33 g $/cm^3$
C) 3.33 x 10^{-4} m^3/kg
D) 0.33 $m^3/$ kg

Solution:

m= 600 g = 0.6 kg
V = 200 cm^3= 0.0002 m^3
specific volume = 0.0002 / 0.6 = 3.33 x 10^{-4} m^3/kg

3.171. Which is the correct formula?
A) $\Delta V=\alpha V \Delta T$
B) $\Delta V=\beta V \Delta t$
C) $\Delta V=\alpha V \Delta t$
D) $\Delta V=2\alpha V \Delta t$

3.172. Calculate ΔV, when $V=2m^3$; $t_1= 12$ °C; $t_2=25$°C; $\alpha=10^{-4}$ K^{-1}

Solution:

$\Delta V=\alpha V \Delta t$

$\Delta V= 10^{-4} \times 2 \times 13 = 2.6 \times 10^{-3}$ m^3

3.173. State True or False

A) if something has high compressibility it has a low Bulk modulus
B) if something has high compressibility it has a high Bulk modulus

3.174. State True or False

A) compressibility = change in pressure due to change in volume
B) The bulk modulus is analogous to the modulus of elasticity for solids
C) the volume modulus of elasticity known as the bulk modulus
D) water has a minimum compressibility at about 50°C
E) The compressibility is the reciprocal of the Bulk modulus
F) liquid has higher compressibility than gas
G) in the nature all the fluids are compressible

4. HYDROSTATICS

4.1. State True or False

The Hydrostatics is…

A) the branch of fluid mechanics
B) categorized as a part of the fluid statics
C) Some principles of hydrostatics have been known in an empirical and intuitive sense since medieval
D) is the mechanics of fluids in static equilibrium

4.2. Comparison liquids and gases - Fill up the missing spots in the table below!

	LIQUIDS	GASES
SHAPE	A)………………………………	Takes up the shape of the container
FLUIDITY	B)………………………………	C)………………………
VOLUME	Fixed volume	D)……………………
COMPRESSIBILITY	E)………………………………	F)………………………

- Not easy to compress
- Flows easily
- Changes volume to fill its container
- Takes up the shapeof the container
- Flows easily
- Easy to compress

4.3. Fill up the missing spots in the table below!

A)…………………………… ……………………………..	Archimedes' Principle C)…………………… ……………………..	B)……………………… …………………… D)…………………… ………………………..
Heron of Alexandria	E)…………………… ………………………	it is not a perpetual motion machine
F)…………………………… ……………………………..	Pascal’s law	G)…………………… ………………………..
Torricelli	H)…………………… ………………………	I)……………………… ………………………..
J)…………………………… ……………………………..	Bernoulli's principle	K)…………………… ………………………..

- Archimedes
- increased fluid speed decreased internal pressure
- Heron's fountain
- principle of transmission of fluid-pressure
- physical law of buoyancy
- Daniel Bernoulli
- weight of displaced fluid
- Atmospheric Pressure
- mercury barometer
- Buoyancy
- Blaise Pascal

4.4. Fill in the blanks.

A fluid is said to be in hydrostatic equilibrium or………………………………………………. when it is at ………………., or when the flow velocity at each point is ………………………………….. over time.

4.5. The symbol of the weight density

A) D

B) w

C) wd

D) γ

4.6. The unit of the weight density

A) kg/ms

B) kN

C) kg $\cdot$m/s^2

D) kg/m^3

4.7. The weight density is given by

A) $w = \gamma$ x g

B) $w = \rho$ x g

C) ρ= w x g

D) γ = w x g

4.8. Calculate the mass.

Density: $\rho = 1270$ kg / m^3

Volume: V = 200 cm^3 = 0.0002 m^3

Solution:

m = ρ x V = 1270 x 0.0002 = 0.54 kg

4.9. Density Converter – Fill in the Blanks

3.2 g/cm^3 = …………………………………………..kg /m^3

12.45 g /liter = ……………………………………..g/cm^3 = ……………………………………………..kg/m^3

2470 kg /m^3 = ………………………………………g /liter = ………………………………………………g /cm^3

4.10. The density of an object is

A) The same as its volume

B) The mass divided by the volume

C) The same as the shape of the object

D) The volume divided by the mass

4.11. Density is a characteristic property of a substance. This means that the density of water stays the same regardless ………………………………

A) of the volume

B) of the mass

C) of the pressure

D) of the weight density

E)

4.12. If the density of water is 3 gram/cm^3, this means that the mass of 300 cm^3 of water should be

A) 300 grams

B) 100 grams

C) 1 gram

D) 900 grams

4.13. Which physical property of matter describes the relationship between mass and volume?

A) specific weight

B) conductivity

C) density

D) weight

4.14. A unit of pressure is called a

A) newton

B) pascal

C) pound

D) barometer

4.15. What is the density of a substance with a mass of 45.00 g and a volume of 26.4 mL?

A) 0.55 g/mL

B) 1.7 g/mL

C) 45.0 g/mL

D) 1188 g/mL

4.16. The pressure at any point in a fluid is defined as the

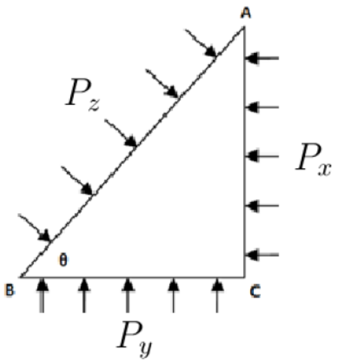
A) intensity of pressure per unit area
B) force x area
C) force per unit area
D) intensity of pressure x unit area

4.17. N/m^2 is known as
A) kPa
B) Pa
C) bar
D) Hgmm

4.18. TRUE or FALSE?
The Pascal's law states that the pressure at a point is equal in all directions in a static fluid.

A) True
B) False

4.19. Consider a very small right angled triangular element ABC of a liquid as shown in figure. p_x is the intensity of horizontal pressure on the element of the liquid. Calculate the total pressure on the vertical side AC of the liquid!



A) $P_x = p_x$ x AC
B) $P_x = p_x$ x AB
C) $P_x = p_y$ x AB
D) $P_x = p_z$ x AC

4.20. Absolute pressure
A) $p_{abs} = p_{atm} - p_{gage}$
B) $p_{abs} = p_{atm} + p_{gage}$
C) $p_{abs} = p_{atm}$
D) $p_{abs} = p_{gage}$

4.21. Pressure head

A) Z= p x (ρ x g)
B) Z= p/(ρ x g)
C) Z= γ x h
D) Z= ρ x g x h

4.22. An open tank contains water upto a depth of 3 m and above
it an oil sp. gr. 0.9 for a depth of 1.5 m. Find the pressure intensity at the interface of two liquids!

Solution:

h_1= 3 m
h_2= 1.5 m
$\rho_1 = \rho_{water}$= 1000 kg/m^3
$\rho_2 = \rho_{oil}$ = 0.9 x 1000 = 900 kg/m^3

p = ρ x g x h

p = ρ_2 x g x h_2 = 900 x 9.81 x 1.5 = 13243.5 N/m^2

4.23.Which of the following is the hydrostatic equation?

A) P = ρgd
B) P = ρgh
C) P/(ρg) = d
D) ρ = P/(gd)

4.24. Which of the following increases with the depth of the liquid?

A) Gravity
B) Density
C) Mass
D) Pressure

4.25. A barometer shows the reading 780 mm merkury. Determine the atmosfera pressure in unit SI.

Solution:

p = ρ x g x h
P = 13600 x 9.81 x 0.780 = 104064.48 N/m^2

4.26. Pascal decides to build a barometer. He can't find any mercury in his laboratory and decides to use water instead. The density of water is 1000 kg/m^3. If the atmospheric pressure is 101.475 kPa how tall must his barometer be in order to obtain an accurate reading? A comparable mercury barometer would be ……………… m tall.

$\rho = 1000\ kg/m^3$
p= 101.475 kPa = 101475 Pa
h=?

Solution:

$p = \rho \times g \times h$

$h = p / (\rho \times g)$

h = 101475 / (1000 x 9.81) = 10.344 m

A comparable mercury barometer:

p= 101.475 kPa = 101475 Pa

$\rho_{mercury} = 13600\ kg/m^3$

h = ?

h = 101475 / (13600 x 9.81) = 0.7605 m

4.27. Factors Affecting Air Pressure - Fill up the missing spots in the table below!

FACTOR	CHANGE OF THE FACTOR	AIR PRESSURE
DENSITY	increase	A)……………………………
	B)………………………	decrease
ALTITUDE	increase	C)………………………………
	decrease	D)……………………………
TEMPERATURE	increase	E)………………………………
	F)……………………	increase
WATER VAPOR	increase	G)……………………………
	decrease	H)……………………………

4.28. Determine the pressure in kN/m^2 at the 10 m under surface of oil. The specific gravity is 0.75!

Solution:

$p = \rho \text{ x } g \text{ x } h$

Specific Gravity = Relative Density dimensionless unit defined as the ratio of the density of a substance to the density of water

$SG = \rho_{substance} / \rho_{H2O}$

SG = Specific Gravity of the substance
$\rho_{substance}$ = density of the fluid or substance [kg/m^3]
ρ_{H2O} = density of water - normally at temperature 4 °C [1000 kg/m^3]

$0.75 = \rho_{substance} / 1000$
$\rho_{substance} = 750 \ kg/m^3$

$p = 750 \text{ x } 9.81 \text{ x } 10 = 73575 \ N/m^2 = 73.575 \ kN/m^2$

4.29. A hydraulic press has a diameter ratio between the two pistons of 6:1. The diameter of the larger piston is 660 mm and it is required to support a mass of 4200 kg. The press is filled with a hydraulic fluid. The specific gravity of the hydraulic fluid is 0.8.
Calculate the force required on the smaller piston to provide the required force when the two pistons are at the same level!

Solution:

6 : 1
660 mm : 110 mm

$A_2= [(d_1)^2 x\ \pi] / 4 = [0.66^2 x\ \pi] / 4 = 0.342\ m^2$

$A_1= [(d_2)^2 x\ \pi] / 4 = [0.11^2 x\ \pi] / 4 = 0.009\ m^2$

$F_1 / A_1 = F_2 / A_2$

$F_1 / 0.009 = (4200\ x\ 9.81) / 0.342$

$F_1= 1084.26\ N$

4.30. A container is filled with oil (the volume of oil is 7.4 m^3; the mass of oil is 6200 kg). Determine:

a) the relativ density
b) the hydrostatic pressure on the bottom of the container, when h=1.2 m
c) the absolute pressure on the bottom of the container

Solution:

a) $\rho_{rel} = \rho_{substrat} / \rho_{water}$

$\rho_{substrat}= m/V = 6200 / 7.4 = 837.84\ kg/m^3$

$\rho_{rel}= 837.84 / 1000 = 0.8378$

b) $p = \rho\ x\ g\ x\ h = 837.84\ x\ 9.81\ x\ 1.2 = 9863.05\ Pa$
c) $p_{abs}= p_0+ (\rho\ x\ g\ x\ h) = 10^5+ 9863.05 = 109683.05\ Pa$

4.31. Seawater in a Marine aquarium 8 m deep. The density of
the seawater is 1025 kg/m^3. What is the force acting on the base, when the rectangular base is 10 m wide and 20 m long?

$F = p \times A$

$p = \rho \times g \times h = 1025 \times 9.81 \times 8 = 80442$ Pa

$A = 10 \times 20 = 200$ m^2

$F = 80442 \times 200 = 16088400$ N

4.32. We had an object submerged in water with the top part touching the atmosphere. The force of the water pressing up. The calculation of the force

A) $F_{water} = F_{atm}$

B) $F_{water} = F_{atm} + mg$

C) $F_{water} = - F_{atm}$

D) $F_{water} = F_{atm} – mg$

4.33. Calculate the absolute pressure at an ocean depth of 2.41 km Calculate the total force exerted on the outside of a 55 cm diameter circular submarine window. The density of the ocean water is 1027 kg/m^3.

$p_0 = 1.01 \times 10^5$ Pa

$h = 2.41$ km $= 2410$ m

$d = 55$ cm $= 0.55$ m => $r = d/2 = 0.275$ m

$\rho_{ocean\ water} = 1027$ kg/m^3

$p = p_0 + \rho gh$

$p = (1.01 \times 10^5) + (1027 \times 9.81 \times 2410) = 2.438 \times 10^7$ N/m^2 $= 2.438 \times 10^7$ Pa

$p = F / A = F/ (r^2\pi)$

$2.438 \times 10^7 = F / (0.275^2\ \pi)$

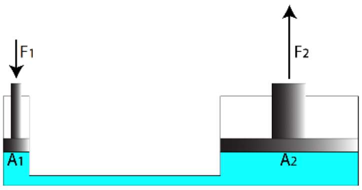
$F = 5.778 \times 10^6$ N

4.34. True or false? Pascal's Principle - Pressure is transmitted undiminished in an enclosed static fluid.

A) True

B) False

4.35. You have a closed container filled with an incompressible fluid with two pistons of differing areas, A_1 and A_2. How can you create p_1 pressure in the fluid?



A) $p_1 = p_2$

B) $p_1 = F_1 / A_1$

C) $p_1 = F_2 / A_1$

D) $P_1 = F_1 \times A_1$

4.36. True or false? A hydraulic system is a device in which a small applied force can give rise to a smaller force.

A) True
B) False

4.37. Applications of Pascal's Principle in Everyday Life. Which is the Odd One Out?

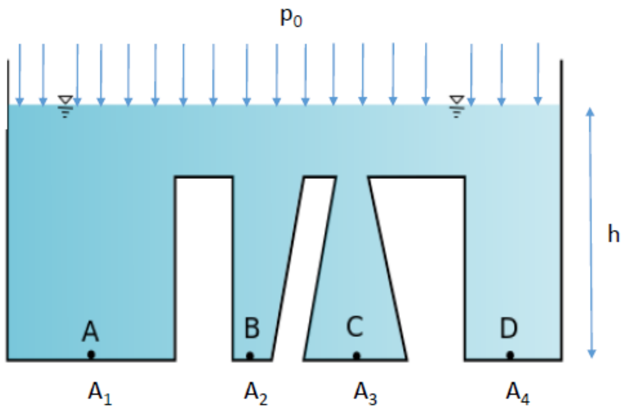
A) Hydraulic Jacks

B) Hydraulic Pumps

C) Hydraulic Jump

D) Hydraulic Brakes

4.38. Which is the Odd One Out?



A) $p_B < p_D < p_C < p_A$

B) $h_A = h_B = h_C = h_D$

C) $p_A = p_{atm} + \rho g h$

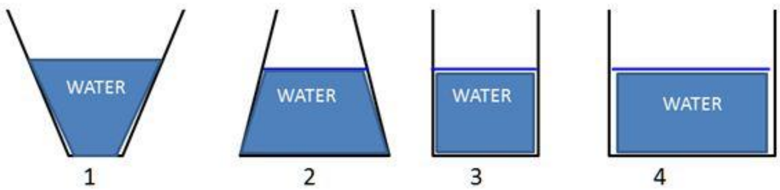
D) $p_C = p_D$

4.39. True or False? The shape of a container does not matter in hydrostatics.

A) True

B) False

4.40. True or False?



A) The water exerts the greatest pressure on the base of vessel 4

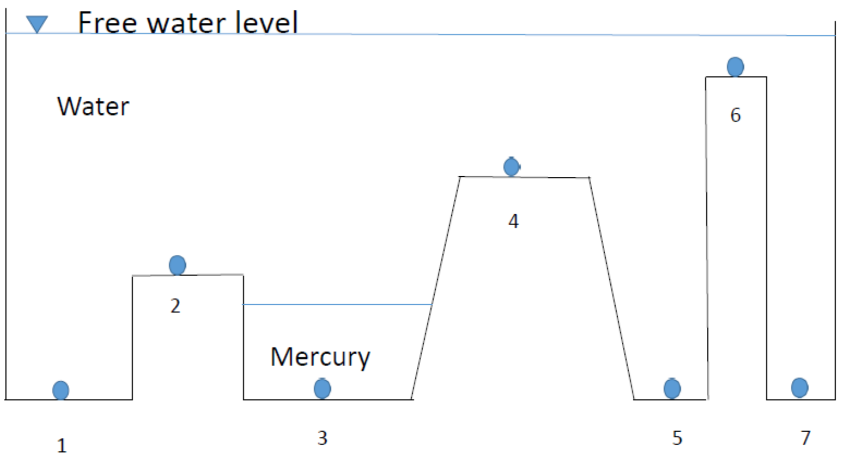
B) Each vessel contains the same depth of water

C) Pressure doesnt depend on the volume of the container

D) The water exerts the same force on the base of vessel 2 and vessel 4

E) A fluid can not support its self without a container

4.41. The container was filled water and mercury



A) $p_1 = p_5 = p_7$

B) $p_3 > p_7$

C) Any free surface open to the atmosphere has atmospheric pressure, p_0

D) The absolute pressure in point 3 is: $p_3 = p_0 - (\rho_{Hg} \text{ x } g \text{ x } h_{Hg})$

E) the gage pressure in point 4 < the gage pressure in point 6

F) p_3 does not equal p_5

4.42. True or false?

A) Buoyant force = weight of displaced water

B) An object will float in a fluid if the density of that object is more than the density of the fluid.

C) The buoyancy force always points upwards because the pressure of a fluid increases with depth.

D) The buoyancy force does not depend on the shape of the object, only on its volume.

E) $\Delta p = p_{top} - p_{bottom}$

F) An object floats if the buoyancy force exerted on it by the fluid balances its weight

G) Bouyant force is the weight of the mass of water displaced by an immersed object

H) For a fully submerged object, apparent immersed weight =
weight of object - weight of displaced fluid

I) The buoyancy force always points upwards because the pressure of a fluid decreases with depth.

J) Density doesn't play a crucial role in Archimedes' principle.

K) Specific gravity is the ratio of the density of an object to a fluid (usually sea water).

4.43. When did Archimedes discover buoyancy?

A. While swimming in a lake

B. While taking a bath

C. While watching shark in the sea

D) While speaking with the King

4.44. Up thrust of body is equal to the

A) weight of liquid
B) mass of liquid
C) weight of liquid displaced
D) density of liquid

4.45. Weight of a metal bar in water is 0.42 N and in air is 0.48, its density would be

A) 3000 kg /m^3

B) 6000 kg / m^3

C) 9000 kg / m^3

D) 8000 kg/m^3

4.46. The weight of a liquid depends mainly upon

A) how much pressure it contains

B) how dense it is

C) how much force it contains

D) how deep the container is

4.47. Archimedes' principle compares the relationship between buoyancy and

A) buoyant force

B) volume

C) pressure

D) displaced fluid

4.48. The statement that any change in pressure of a fluid is transmitted uniformly, in all directions, throughout the fluid is known as

A) Boyle's law

B) Pascal's principle

C) Boyle's law

D) Archimedes law

4.49. What did Archimedes supposedly shouted while running through the street naked?

A) „Houston, we have a problem!"

B) "Open Sesame!"

C) "Eureka! Eureka!"

D) „Breaking news!"

4.50. Which of the following statements is false?

A) The pressure difference in a vertical U-Tube manometer can be expressed as ρ x g x h

B) The pressure difference in a inclined U-tube manometer can be expressed as pd= γ x h x sin(θ)

C) An inclined manometer is designed to measure higher values of pressure than the U-tube manometer

D) The pressure difference in a vertical U-Tube manometer can be expressed as p= γ x h

4.51. Which of the following statements is true?

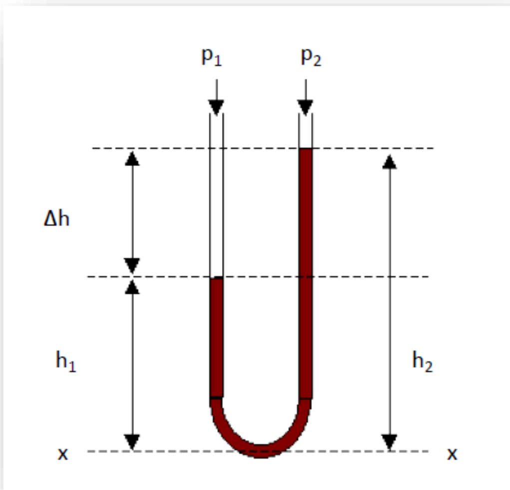
A) The common types of manometer are the U-tube, the Well and the Inclined manometer

B) The common types of manometer are the U-tube, and the the Well manometer

C) The common types of manometer are the U-tube, and the Inclined manometer

D) The common types of manometer are the U-tube, the Well, the Inclined and the mercury manometer

4.52. The U-tube manometer is filled with a fluid (ρ). ρ_1 is the density of the measurand fluid. The difference in the height of the two columns is due to the fact that p_1 is greater than p_2. Which of the following statements is false?



A) $p_1 + \rho_1 \times g \times \Delta h + \rho \times g \times h_1 = p_2 + \rho \times g \times h_2$
B) The pressure in the right limb is due to the column of measuring fluid of height h_2 and the pressure p_0
C) $\Delta h = h_2 - h_1$
D) $\Delta p = \rho \times g \times \Delta h$

4.53. Characteristics of an ideal U-Tube manometer. Which is the Odd One Out?

A) cost efficient

B) for large pressure differences mercury can be used

C) no calibration

D) It is able to measure high changes in pressure

4.54. A U-tube about half filled with liquid, with both ends of the tube open, the liquid is

A) at the same height in each leg
B) at the different height in each leg

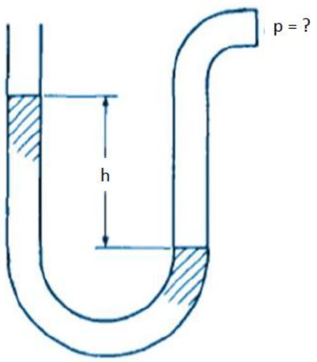
4.55. The measured pressure is

A) $p = p_0$

B) $p = p_0 - \rho \times g \times h$

C) $p = p_0 + \rho \times g \times h$

D) $p = \rho \times g \times h$



4.56. U-Tube Manometer Measuring Pressure

Density: 800 kg/m^3

Height Difference: 0.85 m

Acceleration of gravity: 9.81 m/s^2

Pressure =?

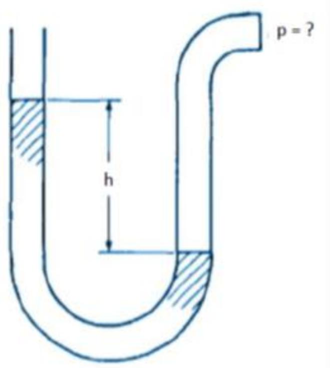
Solution:

$\rho = 800\ kg/m^3$

$h = 0.85\ m$

$g = 9.81\ m/s^2$

$p = \rho \times g \times h = 800 \times 9.81 \times 0.85 = 6670.8\ N/m^2$



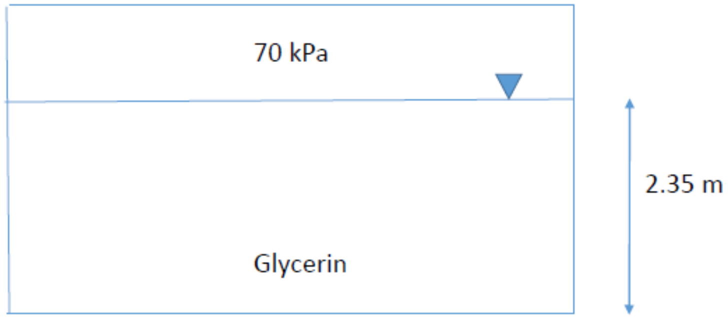
A) $667080\ N/m^2$

B) $6670.8\ N/m^2$

C) $6.671\ N/m^2$

D) $667.08\ N/m^2$

4.57. For the vessel containing glycerin under pressure. Find the pressure at the bottom of the tank.



Solution:

p = 70 kPa = 70000 Pa

h= 2.35 m

γ= 12.34 kN/m^3= 12340 N/m^3

$p' = p + \gamma \cdot h$ = 70000 + (12340 x 2.35) = 98999 Pa = 98.999 KPa

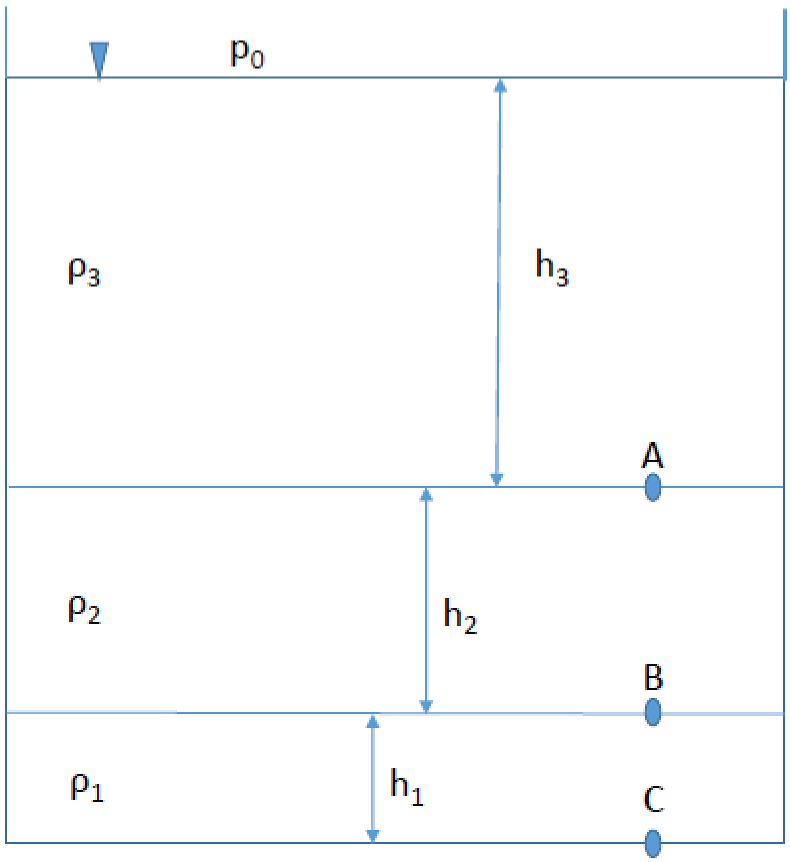
4.58. The container was filled with different fluids (densities of the fluids: ρ_1, ρ_2, ρ_3). Calculate the hydrostatic pressure and the absolute pressure in point A, B, C!

ρ_1 = 13600 kg/m^3

ρ_2 = 1000 kg/m^3

ρ_3 = 800 kg/m^3

h_1 = 0.6 m; h_2=1.2 m ; h_3= 2.5 m



p0
ρ3
h3
A
ρ2
h2
B
ρ1
h1
C

A:

$p_A = \rho_3$ x g x h_3 = 800 x 9.81 x 2.5 = 19620 Pa

$p_{abs} = p_0 + p_A$ =100000 + 19620 = 119620 Pa

B:

$p_B = \rho_2$ x g x h_2= 1000 x 9.81 x 1.2 = 11772 Pa

$p_{abs} = p_0$ + (ρ_3 x g x h_3) + (ρ_2 x g x h_2) = 100000 + (800 x 9.81 x 2.5) + (1000 x 9.81 x 1.2) = 131392 Pa

C:

$p_C = \rho_1$ x g x h_1 = 13600 x 9.81 x 0.6 = 80049.6 Pa

$p_{abs} = p_0 + \rho_3$ x g x h_3 + ρ_2 x g x h_2+ ρ_1 x g x h_1= 100000 + (800 x 9.81 x 2.5) + (1000 x 9.81 x 1.2) + (13600 x 9.81 x 0.6) = 211441.6 Pa

4.59. Pressure Variation in a Fluid at Rest

$$\frac{\partial p}{\partial x} = 0$$

$$\frac{\partial p}{\partial y} = 0$$

$$\frac{\partial p}{\partial z} = ?$$

A) 0

B) γ

C) $-\gamma$

D) 1

4.60 Matching

A) $dp/dz=-\gamma$

B) $F_R= \gamma \times h_c \times A$

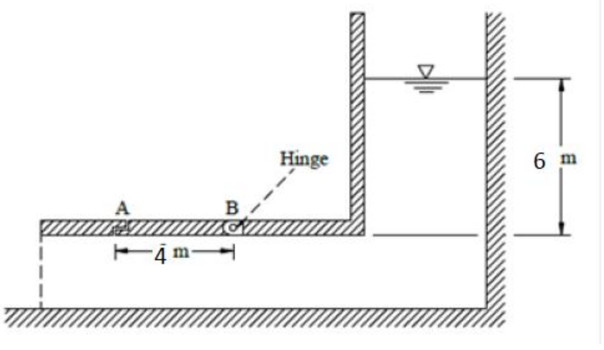
C) $y_r = I_{xc} / y_c \times A + y_c$

D) $x_r = I_{xyc} / y_c \times A + x_c$

E) $F_b=\gamma \times V_{disp}$

1. buoyant force
2. hydrostatic force on a plane surface
3. Location of hydrostatic force on a plane
4. pressure gradient in a stationary fluid

4.61. To prevent water pressure from pushing gate AB open, a small extension, or lip, is provided at A. If the gate is 6-m wide (measured perpendicular to the plane of the figure), determine the force acting on the lip. The density of water is 10^3 kg/m^3.



Solution:

p_{AB}= ?

$p_{AB}= \rho \times g \times h = 1000 \times 9.81 \times 6 = 58860$ Pa = 58.86 kPa

Convert the pressure to a force per length by multiplying by the width:

$p = p_{AB} \times$ width

p = 58860 x 6 = 353160 Pa

We can write the equilibrium equation for gate AB

$\sum M_B = F_A \times 4 - (353160 \times 4 \times 4/2) = 0$

$F_A = 706320$ N = 706.32 kN

5. FLUID KINEMATICS - CONTINUITY EQUATION

5.1. What is the Continuum Hypothesis?

A) Fluid particle not molecular

B) fluid isn't described as a continuum

C) a fluid is described as a continuum

D) the continuum model allows us to have to deal with molecular interaction directly

5.2. Flow patterns can be visualized using:

A)…………………………………………………………………..

B) …………………………………………………………………..

C) …………………………………………………………………..

D)…………………………………………………………………..

5.3. Definition of timeline

……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………

5.4. Definition of pathline

……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………

5.5 Definition of streamlines

……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………

5.6.

In a steady flow, …..…………………………………………..,
……………………………………………………..,
and…………………………………………………… are identical lines in the flow field.

The difference between a fluid and a solid is, that stresses in a fluid are mostly generated by …………………………………………………. rather than by ……………………………………………………..

Streamlines: they are ………………………………… to the direction of …………………………….. at every point in the flow field.

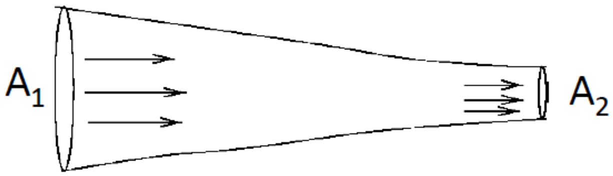
In steady flow, the ………………………………….. at each point in the flow field remains …………………………………………… with time.

The stress at a point is specified by the ………………………………components, where σ has been used to denote a …………………………………..stress, and τ to denote a …………………………………….. stress:

$$\begin{bmatrix} \sigma_{xx} & \tau_{xy} & \tau_{xz} \\ \tau_{yx} & \sigma_{yy} & \tau_{yz} \\ \tau_{zx} & \tau_{zy} & \sigma_{zz} \end{bmatrix}$$

Viscous flow can be ………………………………………… or …………………………………………………….. .

5.7.

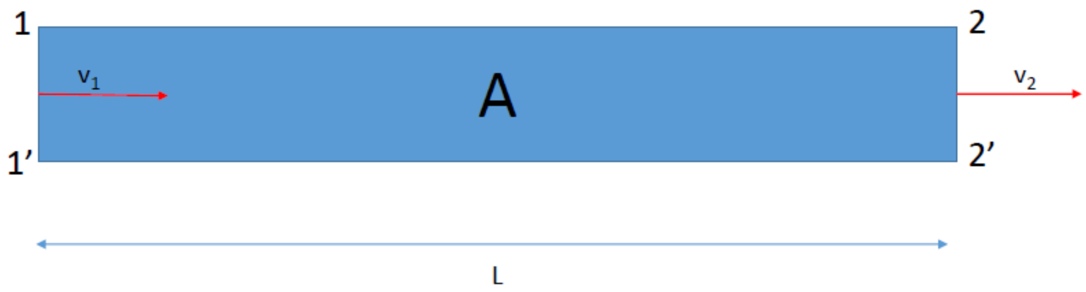


A1 : ………………………………….. hose ; ………………………………………. speed

A2: ………………………………… hose ; ………………………………………. speed

- **A) narrower**
- **B) slower**
- **C) faster**
- **D) wider**

5.8. Volumetric flow rate



Volume of fluid in element:

…………………………………………………………………………………………..

Velocity of fluid:

…………………………………………………………………………………………
……………

Volummetric flowrate:

…………………………………………………………………………………………
.

5.9.

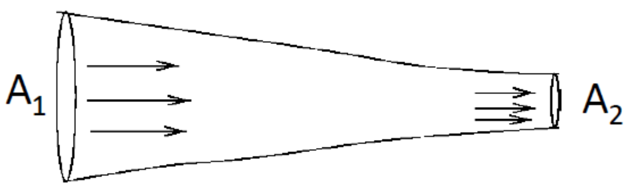
$d_1 = 0.2$ m

$v_1 = 6$ m/s

$d_2 = 0,1$ m

$v_2 = ?$

$Q = ?$



Solution:

$d_1 = 0.2$ m => $A_1 = (d_1^2\pi) / 4 = (0.2^2\pi) / 4 = 0.0314$ m^2

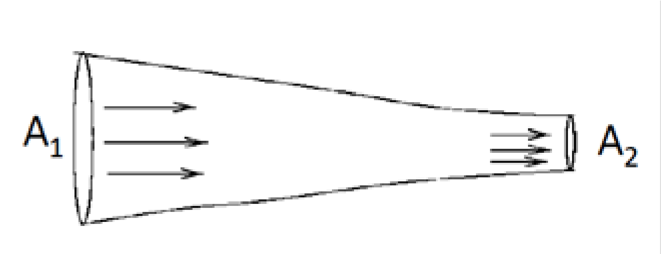
d_2= 0.1 m => A_2= $(d_2^2\pi) / 4 = (0.1^2\pi) / 4 = 0.00785$ m^2

$Q_1 = A_1 \times v_1 = 0.0314 \times 6 = 0.1884$ m^3/ s

$Q_1 = Q_2 = 0.1884$ m^3/ s

$v_2 = Q_2 / A_2 = 0.1884 / 0.00785 = 24$ m/s

5.10. Determine the volume flow in over ; the volume flow out over; the mass in over ; the mass out over!



Volume flow in over:……………………………………………………………………………………

Volume flow out over:……………………………………………………………………………………

Mass in over:……………………………………………………………………………………

Mass out over:…………………………………………………………………………………

Volume flow in over: $A_1 = A_1 \times V_1 \times \Delta t$

Volume flow out over: $A_2 = A_2 \times V_2 \times \Delta t$

Mass in over: $\rho \times A_1 \times V_1 \times \Delta t$

Mass out over: $\rho \times A_2 \times V_2 \times \Delta t$

$\rho \times A_1 \times V_1 = \rho \times A_2 \times V_2$

5.11. The continuity equation is only applicable to
incompressible fluid.

a) True

b) False

Explanation: The continuity equation is only applicable to incompressible as well as compressible fluid.

5.12. What is the most common assumption while dealing with fluid flow problems using continuity equation?

a) Flow is assumed to be compressible

b) Flow is assumed to be unsteady

c) Flow is assumed to be steady

d) Flow is assumed to be turbulent

Explanation: In majority of the fluid flow problems, flow is assumed to be steady.

5.13. For compressible fluid flow in a pipe, having decrease in specific gravity what will be the effect of decrease in diameter?

a) It will cause increase in velocity

b) It will cause decrease in velocity

c) It remains constant

d) None of the mentioned

Explanation: According to continuity equation,

$\rho*A*v = \text{constant}$

Hence, as density and area decreases velocity is bound to increase.

5.14. The continuity equation is based on the premise of-

a) Law of conservation of energy

b) Law of conservation of mass

c) Law of conservation of momentum

d) None of the mentioned

Explanation: Continuity equation is based on the the principle of conservation of mass.

5.15. If a liquid enters a pipe of diameter d with a velocity v, what will it's velocity at the exit if the diameter reduces to 0.5d?

a) v

b) 0.5v

c) 2v

d) 4v

5.16. The continuity equation is based on the principle of

a) conservation of mass

b) conservation of momentum

c) conservation of energy

d) conservation of force

Explanation: According to the Continuity Equation, if no fluid is added or removed from the pipe in any length then the mass passing across different sections shall be the same. This is in accordance with the principle of conservation of mass which states that matter can neither be created nor be destroyed

5.17. Two pipes of diameters d1 and d2 converge to form a pipe of diameter 2d. If the liquid flows with a velocity of v1 and v2 in the two pipes, what will be the flow velocity in the third pipe?

a) v1 + v2

b) v1 + v2/2

c) v1 + v2/4

d) 2(v1 + v2)

5.18. Two pipes, each of diameter d, converge to form a pipe of diameter D. What should be the relation between d and D such that the flow velocity in the third pipe becomes double of that in each of the two pipes?

a) D = d

b) D = 2d

c) D = 3d

d) D = 4d

$A_1v_1 + A_2v_2 = Av$
$d^2v + d^2v = D^2v$
D = d.

5.19. Two pipes, each of diameter d, converge to form a pipe of diameter D. What should be the relation between d and D such that the ow velocity in the third pipe becomes half of that in each of the two pipes?

a) D = d/2

b) D = d/3

c) D = d/4

d) D = d/5

$A_1v_1 + A_2v_2 = Av$
$d^2v + d^2v = D^{v/2}$
d = D ⁄ 4.

6. PRESSURE AND FLUID STATICS

6.1. Convert a pressure head of 15 m of water column to kerosene of specific gravity 0.8 and carbon-tetra-chloride of specific gravity of 1.62.

Height of water column, $h_1 = 15$ m
Specific gravity of water $SG_1 = 1.0$
Specific gravity of kerosene $SG_2 = 0.8$
Specific gravity of carbon-tetra-chloride, $SG_3 = 1.62$

Solution:

Weight of the water column = Weight of the kerosene column

$\rho \times g \times h_1 \times SG_1 = \rho \times g \times h_2 \times SG_2 = \rho \times g \times h_3 \times SG_3$

$1000 \times 9.81 \times 15 \times 1.0 = 1000 \times 9.81 \times h_2 \times 0.8 = 1000 \times 9.81 \times h_3 \times 1.62$

$h_2 = 18.75$ m

$h_3 = 9.26$ m

6.2. A vertical gate of 7 m height and 4.5 m wide closes a tunnel running full with water. The pressure at the bottom of the gate is 225 kN/m ^{2}. Determine the total pressure on the gate.
$P = 225$ kN/m^2

Solution:
Area of the gate = 7 x 4.5 = 31.5 m^2

$h = P / (\rho \times g) = 225000 / (1000 \times 9.81) = 22.93$ m

$F = \rho \cdot g \cdot x \cdot A$

$x = 22.93 - 3.5 = 19.43$ m

$F = 1000 \times 9.81 \times 19.43 \times 31.5 = 6004161.45$ N = 6004.16 kN

6.3. Determine (a) the gauge pressure and (b) The absolute pressure of water at a depth of 17 m from the surface. Density of seawater: 1030 kg/m^3. The standard atmospheric pressure is 101.213 kN/m^2.

Solution:

h = 17 m
ρ= 1030 kg/m^3

p = ρ x g x h = 1030 x 9.81 x 17 = 171773.1 N/m^2 [Pa]

The gauge pressure is the pressure above the normal atmospheric pressure => p = 171773.1 N/m^2

The absolute pressure is: $P_{abs}= p_0 + p$ = 101213 + 171773.1 = 272986.1 N/m^2= 272.98 kN/m^2

6.4. What is the force acting on a 45 meter width dam with the thickness of 6 meter and water with a depth of 35 meters? Draw pressure prism!

Solution:

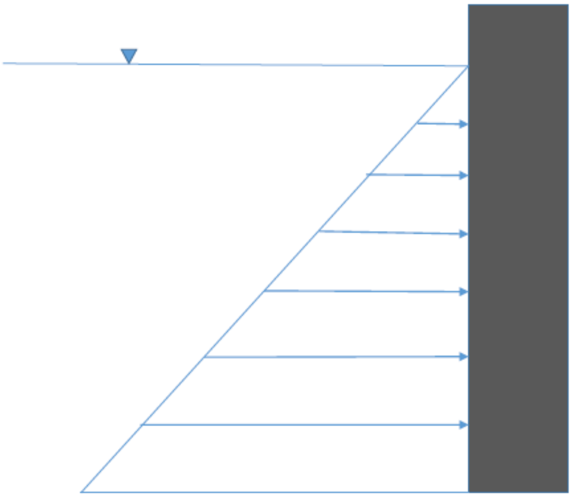
Force on the dam= pressure of the water x Area

The area refers to the surface of the dam that come into direct contact with the water.

F= (density of water) x (acceleration of gravity) x (height of the water/2) x (width of the dam (x) height of the water)

F = [ρ x g x (h/2)] x (w x h)

F= [1000 x 9.81 x (35/2)] x (45x35) = 270388.12 kN



6.5. True or false?
The buoyant force is the weight of the volume of water displaced by the immersed object.

A) True
B) False

6.6. A person is swimming in the ocean. If this person swims to a depth of 3 m below the surface of the water, how much pressure does this swimmer experience? Density of saltwater: 1025 kg/m^3.

p_0 = 101325 Pa

Absolute pressure =?

$p_{abs} = p_0 + \rho \times g \times h = 101325 + (1025 \times 9.81 \times 3) = 131490.75$ Pa = 131.49 kPa

6.7. Typical Forces for a Gravity Dam
For any size of gravity dam, typical forces included in a two-dimensional stability analysis include:

……………………………………………………………………………………..
……………………………………………………………………………………..
……………………………………………………………………………………..
……………………………………………………………………………………..

Headwater
Tailwater
Weight of the dam
Uplift

7. ENVIRONMENTAL IMPACTS OF DAMS

7.1. Which is the highest dam?

A) JINPING 1 (China)
B) GRANDE DIXENCE (Switzerland)
C) ROGUN (Tajikistan)
D) YUSUFELİ (Turkey)

7.2. The Tallest Dam in the United States

A) Hoover Dam
B) Oroville Dam
C) Grand Coulee Dam
D) Cochiti Dam

7.3. Which Dam is the world's largest power station?

A) Krasnoyarsk Dam, Russia
B) Aswan High Dam, Egypt
C) Kariba Dam, Zimbabwe
D) Three Gorges Dam, China

7.4. Types of arch dams

……………………………………………………………………………………..
……………………………………………………………………………………..
……………………………………………………………………………………..
……………………………………………………………………………………..

constant radius arch dam, variable radius arch dam, constant angle arch dam, double curvature arch dam

7.5. Environmental impacts of the Three Gorges Dam

……………………………………………………………………………………..
……………………………………………………………………………………..
……………………………………………………………………………………..
……………………………………………………………………………………..
……………………………………………………………………………………..
……………………………………………………………………………………..
Emissions, Erosion and sedimentation, Earthquakes and landslides, Waste management, Forest cover, Wildlife

7.6. Reasons and Environmental Impacts

	REASONS	ENVIRONMENTAL IMPACTS
Colorado River Basin		
Three Gorges Gam		
Aral Sea Watershed		
Flooding Risks in Bangladesh		
Aswan High Dam		

1. Irrigation and Hydroelectricity
2. Receding sea leaves huge plains covered with salt and toxic chemicals
3. Hydroelectricty and flood control
4. Erosion, waterlogging, soil salinity
5. Prevented water form reaching the mouth of the Colorado River causing an inverse estuary.
6. Each year in Bangladesh around 18% of the country is flooded
7. Greenhouse gas and mercury emission, erosion, sedimentation
8. Flood control
9. Irrigation for cotton
10. Land destructruction, erosion, climate change

7.7. What is the name of the structure that allows fish such to bypass dams on their travel to their spawning grounds?

A) Fish elevator
B) Fish climbing rope
C) Fish way
D) Fish ladder

7.8. Which of these dams, known as one of the "Seven Wonders of the Modern World", generates the most electricity?

A) Hoover dam
B) Three Gorges Dam
C) Itaipu dam
D) Fullerton Dam

7.9. Classification of dam according to its use

……………………………………………………………………………..
……………………………………………………………………………..
……………………………………………………………………………..
……………………………………………………………………………..
……………………………………………………………………………..

Water supply dam
Irrigation dams
Multipurpose dams
Flood control dams
Power dams

7.10.

WEIRS BARRAGES		DAMS	
	mobile		Concrete
Brickwork			

A) Concrete
B) Plain
C) Flap
D) Brickwork
E) mobile
F) Earthfills
G) Arch
H) Rockfills

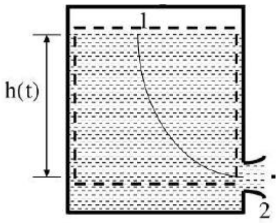
8. BERNOULLI'S EQUATION

8.1. Change in potential energy is measured as difference of

A) M x g
B) m x g x h
C) m x G
D) P/t

8.2. Change in kinetic energy is measured as difference of
A) ¼ mv^2
B) ½ mv
C) ½ mv/2
D) ½ mv^2

8.3. The water tank has a cross-sectional area of 3 m^2.
Calculate the velocity of the water in level 2! h = 4m



Solution:

$v^2 = 2 \times g \times h$
$v^2 = 2 \times 9.81 \times 4$
$v = 8.85$ m/s

8.4. Pressure form of Bernoulli's Equation

……………………………………………………………………………………………….

$p + [\rho \cdot (v^2/2)] + \rho g z = constant$

8.5. „Head" form of Bernoulli's Equation

………………………………………………………………………………………………

$p/ (\rho \cdot g) + v^2/ 2g + z = constant$

8.6. True or false?

Within a horizontal flow of fluid, points of higher fluid speed will have bigger pressure than points of faster fluid speed.

A) True
B) False

Within a horizontal flow of fluid, points of higher fluid speed will have less pressure than points of slower fluid speed.

8.7. A dam holds back the water in a lake. If the dam has a small hole 1.7 meters below the surface of the lake, at what speed does water exit the hole?

Solution:

Let point 1 be on the surface of the lake and point 2 be at the outlet of the hole in the dam. The pressure at each point is just atmospheric pressure, so $p_1 = p_2 = p_0$

$y_1 – y_2 = 1.7$ m

$v_1 = 0$

$p_1 + ½ ρ \cdot v_1^2 + ρ \cdot g \cdot y_1 = p_2 + ½ ρ \cdot v_2^2 + ρ \cdot g \cdot y_2$

$2g (y_1 – y_2) = v_2^2$

$v_2 = 5.77$ m/s

8.8. Bernoulli's Equation for Real Fluids

A) $z_A + p_A/γ + v_A^2/2g = z_B + p_B/γ + v_B^2/2g$
B) $z_A - p_A/γ + v_A^2/2g = z_B + p_B/γ + v_B^2/2g - \sum h_L$
C) $z_A + p_A/γ + v_A^2/2g = z_B + p_B/γ + v_B^2/2g + \sum h_L$
D) $z_A + p_A/γ + v_A/2g = z_B + p_B/γ + v_B/2g + \sum h_L$

8.9. Bernoulli's Equation for Ideal Fluids

A) $z_A + p_A/γ + v_A^2/2g = z_B + p_B/γ + v_B^2/2g$
B) $z_A - p_A/γ + v_A^2/2g = z_B + p_B/γ + v_B^2/2g - \sum h_L$
C) $z_A + p_A/γ + v_A^2/2g = z_B + p_B/γ + v_B^2/2g + \sum h_L$
D) $z_A + p_A/γ + v_A/2g = z_B + p_B/γ + v_B/2g + \sum h_L$

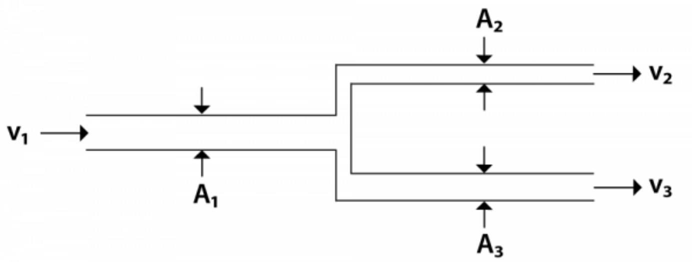
9. FLOW IN PIPES

9.1. Pressure/velocity variation

Q = A1 x v1 = A2 x v2
A2 < A1

A) v2 > v1
B) v2 < v1
C) v2 = v1
D) p2 > p1
E) p2 < p1
F) p2 = p1

9.2. Consider the pipe system shown below in the Figure.



v_1 = 1 m/s
v_2 = 2 m/s
d_1 = 100 mm
d_2 = 30 mm
d_3 = 50 mm

Q_1 =? Q_2 =? Q_3 =? v_3 =?

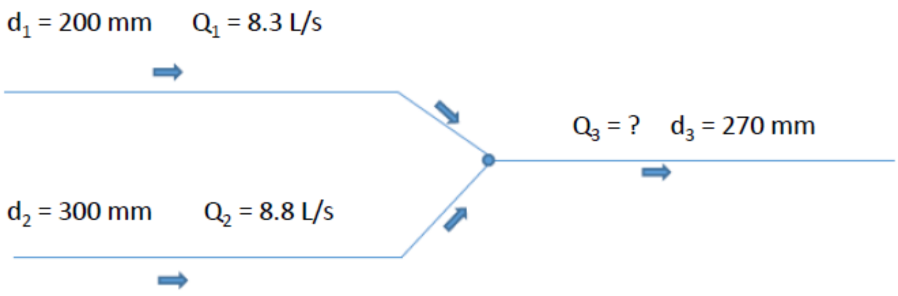
Solution:
Sum of the Flows in = Sum of the Flows out

$A_1 \times v_1 = A_2 \times v_2 + A_3 \times v_3$

$A_1 = (0.1^2 \times \pi) / 4 = 0.00785\ m^2$
$A_2 = (0.03^2 \times \pi) / 4 = 0.000706\ m^2$
$A_3 = (0.05^2 \times \pi) / 4 = 0.00196\ m^2$

$Q_1 = A_1 \times v_1 = 0.00785\ m^3$
$Q_2 = A_2 \times v_2 = 0.001413\ m^3$
$Q_3 = Q_1 - Q_2 = 0.006437\ m^3$
$v_3 = Q_3 / A_3 = 3.284\ m/s$

9.3. Calculate the flow rate (Q_3) and v_1, v_2, v_3 in the pipe!



Solution:

$d_1 = 200\ mm = 0.2\ m$
$A_1 = (d_1^2\pi) / 4 = (0.2^2\pi) / 4 = 0.0314\ m^2$

$Q_1 = 8.3\ L/s = 8.3\ dm^3/s = 0.0083\ m^3/s$

$v_1 = Q_1 / A_1 = 0.0083 / 0.0314 = 0.26\ m/s$

$d_2 = 300\ mm = 0.3\ m$
$A_2 = (d_2^2\pi) / 4 = (0.3^2\pi) / 4 = 0.0706\ m^2$

$Q_2 = 8.8\ L/s = 8.8\ dm^3/s = 0.0088\ m^3/s$

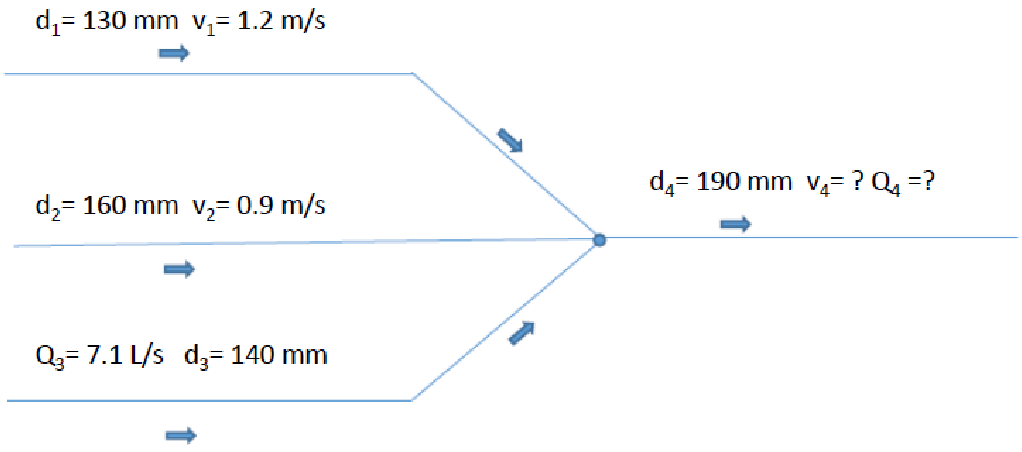
$v_2 = Q_2 / A_2 = 0.0088 / 0.0706 = 0.125\ m/s$

$Q_3 = Q_1 + Q_2 = 0.0083\ m^3/s + 0.0088\ m^3/s = 0.0171\ m^3/s$

$A_3 = (d_3^2\pi) / 4 = (0.27^2\pi) / 4 = 0.057\ m^2$

$v_3 = Q_3 / A_3 = 0.0171 / 0.057 = 0.3\ m/s$

9.4.



d_1= 130 mm = 0.13 m
$A_1 = (d_1^2\pi) / 4 = (0.13^2\pi) / 4 = 0.0132\ m^2$

$Q_1 = A_1 \times v_1 = 0.0132 \times 1.2 = 0.0158\ m^3/s$

d_2= 160 mm = 0.16 m
$A_2 = (d_2^2\pi) / 4 = (0.16^2\pi) / 4 = 0.02\ m^2$

$Q_2 = A_2 \times v_2 = 0.02 \times 0.9 = 0.018\ m^3/s$

Q_3= 7.1 L/s = 7.1 dm^3/s = 0.0071 m^3/s
$A_3 = (d_3^2\pi) / 4 = (0.14^2\pi) / 4 = 0.015\ m^2$

$v_3 = Q_3 / A_3 = 0.0071 / 0.015 = 0.473$ m/s

d_4 = 190 mm = 0.19 m
$A_4 = (d_4^2\pi) / 4 = (0.19^2\pi) / 4 = 0.028\ m^2$

$Q_4 = Q_1 + Q_2 + Q_3 = 0.0158\ m^3/s + 0.018\ m^3/s + 0.0071\ m^3/s = 0.0409\ m^3/s$

$v_4 = Q_4 / A_4 = 0.0409 / 0.028 = 1.46$ m/s

10. FLOW IN OPEN CHANNELS

10.1. Rectangular open channel for river - Variables

A = ………..

b = ………..

F = ………..

g = ………..

k = ………..

n = ………..

P = ………..

Q = ………..

R = ………..

S = ………..

v = ………..

a. Slope of channel bottom or water surface
b. Channel bottom width
c. Discharge or flow rate
d. unit conversion factor
e. Wetted perimeter
f. Flow cross-sectional area, determined normal (perpendicular) to the bottom surface
g. Average velocity of the water
h. acceleration due to gravity
i. Hydraulic radius of the flow cross-section
j. Froude number
k. Manning coefficient

A = Flow cross-sectional area, determined normal (perpendicular) to the bottom surface
b = Channel bottom width
F = Froude number
g = acceleration due to gravity
k = unit conversion factor
n = Manning coefficient
P = Wetted perimeter
Q = Discharge or flow rate
R = Hydraulic radius of the flow cross-section
S = Slope of channel bottom or water surface
V = Average velocity of the water

10.2. Flows with ……………… are high velocity flows called supercritical.

A) $F < 1$
B) $F > 1$
C) $F = 1$

10.3. Flows with ………………are low velocity flows called subcritical.

A) $F < 1$
B) $F > 1$
C) $F = 1$

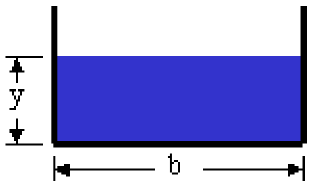
10.4. ………………………..flows are called critical.

A) F < 1
B) F > 1
C) F = 1

10.5. Hydraulic radius of the flow cross-section

A) R = A x P
B) R = A + P
C) R = A / P
D) R = A - P

10.6. Calculate the Area (A), Wetted Perimeter (P), Hydraulic Radius and the velocity (v)



Q = 2 m^3/s
Water Depth = y = 5 m
Width = b = 7 m

Area:
A = y x b = 5 x 7 = 35 m^2

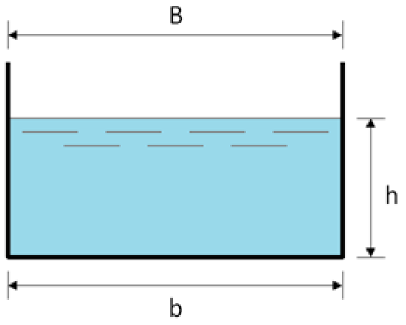
Wetted Perimeter, P:
P = 2y +b = 5+5+7 = 17 m

Hydraulic Radius, R:
R = A / P = 35/17 = 2.06 m

Velocity (v):
v = Q / A = 2 / 35 = 0.057 m/s

10.7. Hydraulic radius=?

b = 4.5 m ; h = 3m

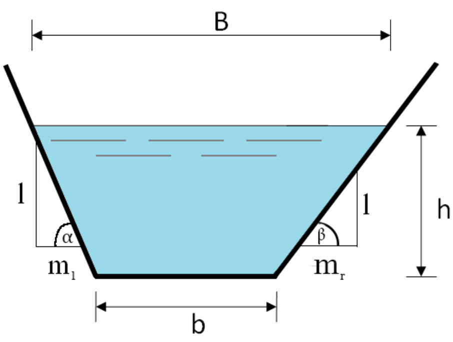


A) R = 1.3857 m
B) R = 1.2857 m
C) R = 1.2867 m
D) R = 1.2957 m

Solution:

Width b: 4.5 [m]
Height h: 3.0 [m]
Arera: 13.5 [m^2]
Wetted perimeter: 10.5 [m]
Hydraulic radius Rh: 1.2857 [m]

10.8. Calculate the angle of slope α and the angle of slope β and the Hydraulic Radius (R)!

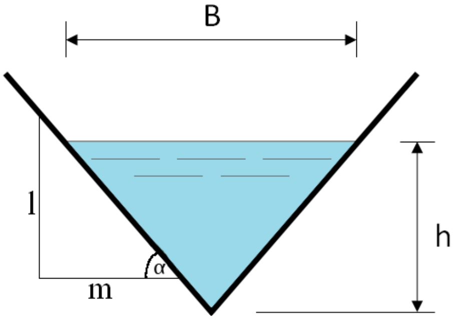


slope m_1 = 1 m
slope m_r = 2 m
b = 4 m
h = 5 m

angle of slope α= ?
angle of slope β= ?
Solution:

Width b: 4.0 [m]
Height h: 5.0 [m]
Slope left: 1.0 [m]
Slope right: 2.0 [m]
Angle of slope α: 45.0°
Angle of slope β: 26.5651°
Width B: 19.0 [m]
Area: 57.5 [m^2]
Wetted perimeter: 22.2514 [m]
Hydraulic Radius R_h: 2.5841 [m]

10.9. Calculate Width (B), Area (A), Wetted perimeter (P) and the Hydraulic radius (R)!



Depth: h = 4.0 m
Slope: 2.0 m
Slope angle: 26.5651°

Solution:

Width: B= 16.0 m
Area: A = 32.0 [m^2]
Wetted perimeter: P = 17.8885 [m]
Hydraulic radius: R =1.7889 [m]

11. ENVIRONMENTAL FLUID MECHANICS PROBLEMS FOR THE 21ST CENTURY

11.1. Most water pollution is caused by ………………………

A) traffic transport
B) sediments
C) human activities
D) droughts

11.2. Which is not a primary use of dams?
A) agricultural uses
B) electricity generation
C) flood control
D) recreation

11.3. Recycling is very important to our environment.
A) True
B) False

11.4. Sludge density
A) 721 kg/ m3

B) 810 kg/ m3

C) 690 kg/ m3

D) 740 kg/ m3

11.5. True or false?
Streamflow is a keystone parameter that impacts many other aspects of a river's hydrology and water quantity.

A) True
B) False

11.6. Water transports substances and properties

PHYSICAL	CHEMICAL	BIOLOGICAL

Metals
Salinity
Dissolved oxygen
Viruses
Color
Bacteria
Suspended solids
Dissolved solids
Turbidity
Heat

11.7. True or false?
The molecular diffusion: the scattering of particles by random turbulent motion.

A) True
B) False

11.8. Forces in a Fluid Environment
Two types of forces are exerted on an object by a fluid environment:

A) ……………………………………………. force due to its immersion in the fluid

B) …………………………………………… force due to its relative motion int he fluid

11.9. True or false?

The Reynolds number is the ratio of a fluid's inertial force to its viscous force.

A) True
B) False

11.10. What are the causes of water pollution?

…………………………………………………………………………………….
…………………………………………………………………………………….
…………………………………………………………………………………….
…………………………………………………………………………………….
…………………………………………………………………………………….
…………………………………………………………………………………….

11.11. True or false?
Metals (Hg, Cu, Cd, Pb, As) in high concentration can be toxic to biota.

11.12. True or false?
As the ocean warms, the density decreases and thus even at constant mass the volume of the ocean increases.

A) True
B) False

11.13.

Salinity ……………………………… within the ocean also have a…………………………………………impact on the local …………………………and thus local sea level, but have ……………………………………effect on global ………………………………………..sea level change.

Solutions

1. History of hydraulics - Some Contributors to the Science of Hydraulics WHO IS WHO?

ARCHIMEDES
a) Greek mathematician
b) physicist and astronomer
c) elementary principles of buoyancy and flotation
d) formulation of a hydrostatic principle
e) Archimedes' principle
f) Archimedes screw

LEONARDO da VINCI
a) elementary principle of continuity
b) many basic flow phenomena
c) designs for hydraulic machinery
d) great pioneer of hydraulics

EVANGELISTA TORRICELLI
a) barometric height
b) barometer
c) Torricelli's theorem
d) describes the parting speed of a jet of water
e) practical applications in daily life
f) relationship between liquid exit velocity and its height in the container

BLAISE PASCAL
a) hydraulic press
b) pressure transmissibility
c) Pascal's law
d) the pressure at a point in a fluid at rest is the same in all directions

ISAAC NEWTON
a) Philosophiæ Naturalis Principia Mathematica
b) foundations of classical mechanics
c) theoretical predictions
d) Opticks: or, A Treatise of the Reflexions, Refractions, Inflexions and Colours of Light
e) mathematical description of gravity
f) Member of Parliament for the University of Cambridge
g) Royal Society
h) key figure of the scientific revolution
i) laws of motion

HENRI de PITOT
a) inventor of the pitot tube
b) French hydraulic engineer
c) flow velocity
d) pitot tube is used to measure the local flow velocity
e) pressure measurement instrument

DANIEL BERNOULLI
a) Swiss mathematician and physicist
b) Bernoulli's principle
c) contemporary and close friend of Leonhard Euler
d) metaphysics
e) natural philosophy
f) Fellow of the Royal Society
g) Conservation of Energy
h) worked with Euler on elasticity
i) Bernoulli's method of measuring pressure
j) energy principle to explain velocity-head indication

LEONHARD EULER
a) infinitesimal calculus
b) graph theory
c) fluid dynamics
d) Swiss mathematician, physicist, astronomer, engineer
e) Euler's number in calculus
f) Euler equation
g) modulus of elasticity
h) graph theory
i) presented a solution to the problem known as the Seven Bridges of Königsberg
j) First explained role of pressure in fluid flow
k) formulated basic equations

ANTOINE CHEZY
a) French hydraulics engineer
b) Chézy formula
c) open channel flow
d) director of the École nationale des ponts et chaussées
e) his equation can be used to calculate mean flow velocity in conduits
f) predicting flow characteristics
g) Chezy's coefficient

GIOVANNI BATTISTA VENTURI
a) Italian physicist
b) discoverer of the Venturi effect
c) Venturi tube
d) Venturi flow meter
e) Venturi pump

HENRI PHILIBERT GASPARD DARCY
a) hydraulic engineer
b) theoretical foundation of groundwater hydrology
c) Darcy’s law
d) conducted experiments on pipe flow
e) calculating head loss due to friction
f) unit of measure of fluid permeability
g) Darcy–Weisbach equation
h) filtration and pipe resistance
i) open-channel studies

JULIUS WEISBACH
a) Professor for applied mathematics, mechanics
b) wrote an influential book for mechanical engineering students
c) foreign member of the Royal Swedish Academy of Sciences
d) Incorporated hydraulics
e) nondimensional coefficients
f) resistance equations

WILLIAM FROUDE
a) ship hydrodynamics
b) hydrodynamicist
c) mathematical expertise with practical experimentation
d) Froude’s law
e) Froude number in hydrology and fluid mechanics
f) indicate the influence of gravity on fluid motion
g) hydraulic jump
h) rise in water surface elevation
i) Fr is less than 1, small surface waves can move upstream
j) Fr is greater than 1, they will be carried downstream
k) Fr = 1 the critical Froude number), the velocity of flow is equal to the velocity of surface waves

ROBERT MANNING
a) Irish hydraulic engineer
b) Manning's coefficient
c) Manning formula for determining open channel flows
d) Handbook of Hydraulics
e) Proposed several formulas for open-channel resistance

OSBORNE REYNOLDS

a) devised two parameters for viscous flow
b) adapted equations of motion of a viscous fluid
c) prominent Irish innovator in the understanding of fluid dynamics
d) Reynolds number
e) ratio of inertial forces to viscous forces
f) Reynolds' turbulence principles
g) Reynolds stress
h) Reynolds number used for modeling in fluid flow

LUDWIG PRANDTL

a) concept of the boundary layer
b) Fluid Flow in Very Little Friction
c) compressibility
d) Prandtl-Glauert correction

LEWIS FERRY MOODY

a) Moody chart
b) first Professor of Hydraulics in the School of Engineering at Princeton
c) method of correlating pipe resistance data

2. Introduction to Fluids

Units and Dimensions

Quantity	Symbol	SI unit
Force	F	N = kg·m/s2
Area	A	m2
Volume	V	m3
Mass	m	kg
Density	ρ	kg/m3
Kinematic viscosity	ν	m2/s
Dynamic viscosity	η	Pa·s
Pressure	p	Pa
Specific weight	γ	N/m3

Temperature	T	K
Velocity	v	m/s
Acceleration	a	m/s2
Time	t	s
Energy	E	J
Power	P	J/s = W
Work	W	J

2.1. Converting Quantities

27 000 cm = 2700 dm

30 000 m2 = 3 x 10^8 cm2

2750 s = 45.833 min = 0.764 h

4.7 km = 4700 m

3.2 h = 192 min = 11520 s

304 km/h = 84.44 m/s

370 K = 97 °C

12.5 m/s = 45 km/h

3 L = 3 dm3 = 0.003 m3

1570 mL = 15.7 dL = 1.57 L

0.25 g / cm3 = 250 kg/m3

5 mol = 5 x 6 x 10^{23} number of particles

6300 kJ = 6300000 J

150 dm2= 1.5 m2

94 °C = 367 K

35600 m = 35.6 km

15 cm3 = 0.015 dm3

35 N/cm2= 350000 Pa

15800 Pa = 15.8 kPa

740 N/m2 = 740 Pa

4,3 t = 4300 kg = 430000 dkg

5200 mg = 5.2 g

3,745 kJ = 3745 J

35500 kW = 35500000 W

4.55 m3= 4550 dm3

13600 kg/m3 = 13.6 g/cm3

30 x 1023 particles = 5 mol

5 N/m3 = 0.005 N/dm3

2 m3/s = 7200 m3/h

12770 N = 12.77 kN

15.67 kN/m3 = 15670 N/m3

457.43 m3= 4.57 x 10^8 cm3

3 MN/m2 = 3000000 Pa

10000 cm2 = 1 m2

23970 mm3 = 23.97 cm3

2.43 GPa = 2430000000 Pa

2.2. A

2.3.

1. true
2. false
3. true
4. true
5. true
6. false
7. false
8. false

9. true
10. true
11. true
12. false
13. false
14. true
15. true
16. true
17. true
18. false
19. true
20. true
21. false
22. true
23. true
24. true

2.4. Comparison liquids and gases

	LIQUID	GAS
TYPES	Solutions Suspensions Emulsions Solvents Sea water plant oils acetone	oxygen Green House gases Sulfur dioxide
PARTICLES	vibrate, move about, and slide past each other close together with no regular arrangement	well separated with no regular arrangement vibrate and move freely at high speeds
SHAPE	assumes the shape of the part of the container which it occupies	assumes the shape and volume of its container
EFFECT OF CHANGE OF PRESSURE ON THE VOLUME	small	large
FREE SPACE BETWEEN PARTICLES	little free space between particles	lots of free space between particles
PARTICLES CAN MOVE	particles can move/slide past one another	particles can move past one another
COMPRESSIBILITY	not easily compressible	compressible
DISTANCE BETWEEN MOLECULES	small	large
ROLE OF INTERACTIONS OF	significant	small, fill the available space

MOLECULES		
CAUSE OF VISCOSITY	attraction among molecules	momentum exchange among molecules

2.5. There are many uses of gases.

GAS		USES
Natural Gas	A)	Cooking
Nitrogen	B)	For oxygen free environment
Argon	C)	electric bulbs and tubes
Chlorine	D)	As sterilizer
Sulfur dioxide	E)	Wine making
Carbon Dioxide	F)	Refrigerant
Neon	G)	electric bulbs and tubes

2.6.

1. true
2. true
3. false
4. true
5. false

2.7.

1. ideal
2. real
3. ideal
4. real
5. ideal

6. real
7. real
8. ideal
9. ideal
10. real
11. real
12. ideal
13. ideal
14. ideal
15. real
16. ideal
17. real
18. ideal
19. real
20. ideal

2.8.

1) fluid statics
2) fluid kinematics
3) fluid dynamics
4) fluid statics
5) fluid kinematics
6) fluid kinematics
7) fluid dynamics
8) fluid kinematics
9) fluid dynamics
10) fluid dynamics
11) fluid dynamics

12) fluid statics

13) fluid statics

14) fluid statics

15) fluid dynamics

16) fluid dynamics

17) fluid dynamics

18) fluid statics

19) fluid statics

20) fluid statics

3. PROPERTIES OF FLUIDS

3.1. B
3.2. A, D
3.3. B
3.4. C
3.5. A
3.6. A
3.7 B
3.8. C
3.9. A
3.10. D
3.11. D
3.12. B
3.13. D

3.14.
A) T
B) F
C) T
D) T
E) F

3.15. B
3.16. B
3.17. A

3.18.

A) false
B) true

3.19. B
3.20. C
3.21. B
3.22. C
3.23. D
3.24. C
3.25. A

3.26. Some common pH values - Fill up the missing spots in the table below!

Sea Water	E
Coffee	B
Cola	G
Milk	D
Hand soap	A
Household ammonia	C
Pure water	F

3.27. True or false?

A) false
B) true

3.28. D
3.29. D
3.30. A
3.31. D

3.32. B
3.33. C
3.34. A
3.35. B
3.36. B
3.37. D

3.38. B
3.39. A
3.40. B
3.41. C
3.42. C
3.43. B
3.44. C
3.45. D
3.46. A
3.47. A
3.48. B
3.49. A
3.50. A
3.51. A
3.52. A
3.53. A

3.54. B

3.55.

A) false

B) true

C) true

D) true

3.56. A

3.57. C

3.58. B

3.59. A

3.60. C

3.61.

$P = (4\gamma) / r$

$\gamma = 0.0370$ N/m

$r = 2.25 \times 10^{-4}$ m

$P = (4 \times 0.0370) / (2.25 \times 10^{-4}) = 657.778$ N/m^2 = 657.778 Pa

SZÉCHENYI 2020

3.62.

$P = (4\gamma) / r$

$\gamma = 0.0728$ N/m

$r = 0.02$ m

$P = (4 \times 0.0728) / 0.02 = 14.56$ N/m^2

3.63. D

3.64.

$h = [(2\gamma\cos\Theta) / (\rho g r)]$

h is the height the liquid is lifted

γ is the liquid-air surface tension

θ is the angle of contact described above

r is the radius of the capillary

3.65. C

3.66.

Surface tension of water at 10 C: $\sigma = 0.0742$ N/m

$\Theta = 0$

$\rho = 1000$ kg/m^3

Solution:

$h = [(2\sigma\cos\Theta) / (\rho g r)]$

$0.004 = [(2 \cdot 0.0742 \cdot \cos 0) / (1000 \cdot 9.81 \cdot r)]$

$r = 0.00378$ m = 3.78 mm

$d = 2 \times r = 2 \times 3.78 = 7.56$ mm (or greater)

3.67. $\sigma = 0.514$ N/m

$\rho = 13570$ kg/m^3

$r = d/2 = 0.004 / 2 = 0.002$ m

Solution:

$h = [(2 \cdot \sigma \cdot \cos\Theta) / (\rho g r)]$

$h = [(2 \cdot 0.514 \cdot \cos 120) / (13570 \cdot 9.81 \cdot 0.002) = -0.0019$ m

3.68.

$\sigma = 0.0712$ N/m

$\rho = 996$ kg/m^3

$r = 0.002$ m

Solution:

$h = [(2 \cdot \sigma \cdot \cos\Theta) / (\rho g r)]$

$h = [(2 \cdot 0.0712 \cdot \cos 0) / (996 \cdot 9.81 \cdot 0.002) = 0.00728$ m $= 7.28$ mm

3.69.

h = height of the water above its free surface

$r2\pi$ = cross-section area of the cylindrical capillary

ρ= density of the water

3.70.

σ : water surface tension
$2r\pi$: circumference of the cylinder
$\cos\alpha$: cosine of the angle of contact

3.71.
d = 7.5 mm
r = d / 2 = 7.5 / 2 = 3.75 mm = 0.00375 m
Θ = 0°
σ = 0.0742 N/m
ρ= 1000 kg/m^3

h = [(2 · σ · cosΘ) / (ρgr)]
h= [(2· 0.0742 · cos0) / (1000 · 9.81 · 0.00375) = 0.00403 m = 4.03 mm

True static height = 27.0 – 4.03 = 22.97 mm

3.72. A

3.73. B => concave

3.74.

h = [(2 · σ ·cos Θ) / (r · ρ · g)]

r = 1.5 mm = 0.0011 m
Θ = 135°
σ= 0.465 N/m
ρ= 13600 kg/m^3

h = [(2 · 0.465 ·cos 135) / (0.0011 · 13600 · 9.81)]

h = [-0.657) / (146.757)]

h = - 0.00447 m = - 4.47 mm

3.75.

A) true
B) false

3.76.

A) false
B) true

3.77. D
3.78. A
3.79. B
3.80. E
3.81. D
3.82. A
3.83. A
3.84. B
3.85. Types of fluids

1. Ideal solid E
2. Ideal plastic fluid D
3. Non Newtonian fluid C
4. Newtonian fluid B
5. Ideal fluid A

3.86.
1. Particles are constantly interacting (B)
2. Viscosity (B)
3. No friction (A)
4. Shear forces oppose motion of one particle past another (B)
5. Incompressible (A)
6. Fluid friction (B)
7. Inviscid (A)
8. Theoretical (A)
9. Isochoric flow (A)
10. Zero viscosity (A)

3.87. True or false?

A) true
B) true
C) true
D) false
E) false
F) false
G) true
H) true
I) true
J) true
K) true
L) true
M) false
N) false
O) true

P) true
Q) false
R) true
S) true
T) true
U) true
V) true
W) true
X) false
Y) false

3.88. B
3.89. C
3.90. A
3.91.B
3.92. B
3.93. B
3.94. B,C
3.95. A,D

3.96.
U_1 = initial internal energy at the start of the process
U_2 = final internal energy at the end of the process
$\Delta U = U_2 - U_1$ = Change in internal energy (used in cases where the specifics of beginning and ending internal energies are irrelevant)
Q = heat transferred into ($Q > 0$) or out of ($Q < 0$) the system
W = work performed by the system ($W > 0$) or on the system ($W < 0$).

3.97. B

3.98. D

3.99. B, D

3.100. B
3.101. C

3.102. Fill up the missing spots in the table below!

A) $dV = 0$
B) $W = pdV = 0$
C) p = constant
D) $W = pdV = p (V2- V1)$
E) $\Delta U = 0$
F) $Q = W$
G) $Q = 0$
H) $\Delta U = W$

3.103. C

3.104. A

3.105. B

3.106. D

3.107.

A) false
B) true
C) true
D) false

3.108.

A) 1662
B) p1 x V1 = p2 x V2
C) Charles' Law
D) V / T = constant
E) fixed p, n
F) 1811
G) V / n = constant

3.109.

ρ= p/RT = 0.27 x 10^6 / [(220) x (24+273)] = 4.13 kg/m^3

m= ρ x V = 4.13 x 0.045 = 0.186 kg

3.110.

p = ρ x R x T

ρ = m/V = 1/0.220 = 4.54 kg /m^3

R = 4.115 kJ/kg·K = 4115 J/kg ·K

T= -55 + 273 = 218 K

p = 4.54 x 4115 x 218 = 4.073 x 10^6 Pa

3.111. C

3.112. B

3.113. D

3.114. A

3.115.

Physical quantities	Units
Temperature	°C, °F, K
Pressure	Pa, kPa, torr, bar, mmHg, atm
Volume	cm^3, m^3

3.116.

Unit	Symbol	Equivalent to 1 atm
Bar	bar	1.01325 bar
Torr	Torr	760 Torr
Millimeter of Mercury	mmHg	760 mmHg
Pascal	Pa	101326 Pa
Kilopascal	kPa	101.326 kPa

3.117. B

3.118. B

3.119.
m = 5 kg
a= 9.81 m/s2
W = F = m x a = 5 x 9.81 = 49.05 N

3.120. B

3.121. C
3.122. D
3.123. A
3.124. B
3.125. C
3.126. A
3.127. C

3.128.
$p_1 \times V_1 = p_2 \times V_2$

$V_2 = (p_1 \times V_1) / p_2$

$V_1 = 22.5 / 1000 = 0.0225\ m^3$

1 [mmHg] = 133.3224 [Pa]

$p_1 = 758$ Hgmm = 101058,38 Pa
$p_2 = 737$ Hgmm = 98258,61 Pa

$V_2 = (101058{,}38 \times 0.0225) / 98258{,}61 = 0.023\ m^3$

3.129.

$p_1 = 1$ atm
$V_1 = 2000\ cm^3 = 2\ dm^3 = 0.002\ m^3$
$V_2 = 1473\ mL = 1.473\ dm^3 = 0.001473\ m^3$
$p_2 = ?$

$p_1 \times V_1 = p_2 \times V_2$

$p_2 = [p_1 \times V_1] / V_2$

$p_2 = [1 \times 0.002] / 0.001473 = 1.358$ atm

3.130. D
3.131. A
3.132. B

3.133.
1. Isobaric (C)
2. Isothermal (D)
3. Volume (B)
4. Isochoric (F)
5. Adiabatic (E)
6. Pressure (A)

3.134. B
3.135. C
3.136. D
3.137. B
3.138. C

3.139.
A) true
B) false
C) true
D) false
E) true
F) true

3.140. A
3.141. D

3.142.

Type of Gas Law	Formula	Description
1.E	2. $p_1 \times V_1 = p_2 \times V_2$	3. H
4. B	5. G	6.D
7.I	8. C	9. J
10. Charles' Law	11. A	12. F
13.	14. $pV = nRT$	

A) $V_1 / T_1 = V_2 / T_2$
B) Combined Law
C) $p_1 / T_1 = p_2 / T_2$
D) Obtained by combining Boyle's Law, Charles' Law and Gay-Lussac's Law
E) Boyle's Law
F) At constant P, as volume increases, temperature increases
G) $(p_1 \times V_1) / T_1 = (p_2 \times V_2) / T_2$

H) At constant T, as pressure increases, volume decreases
I) Gay - Lussac's Law
J) At constant V, as pressure increases, temperature increases

3.143.
$p = 300$ kPa = 300 000 Pa
$T = 290$ K
$V = 380\ 000\ cm^3 = 380\ dm^3 = 0.380\ m^3$

$\rho = p/RT = 300000 / (287 \times 290) = 3.604\ kg / m^3$

$m = \rho \times V = 3.604 \times 0.380 = 1.369$ kg

3.144. A

3.145. B

3.146. B

3.147. A

3.148.

$p_1 = 207$ kPa = 207000 Pa
$R = 287$ J/ kg x K
$T_1 = 28\ °C = 28 + 273 = 301$ K
$V_1 = 100\ dm^3 = 0.1\ m^3$
$p_2 = 490$ kPa = 490000 Pa
$V_2 = 47\ L = 0.047\ m^3$

$\rho_1 = p_1 / RT_1 = 207000 / (287 \times 301) = 2.396\ kg/m^3$

$m_1 = \rho_1 \times V_1 = 2.396 \times 0.1 = 0.2396$ kg

$\rho_2 = p_2 / RT_2$

$\rho_2 = m_2 / V_2 = [0.2396 – 0.003] / 0.047 = 5.034\ kg /m^3$

$5.034 = 490000 / [287 \times T_2]$

$1444.758\ T_2 = 490000$

$T_2 = 339.16$ K

3.149. C

$p_2 = [p_1 \times T_2] / T_1$
$p_1 = 3.7$ atm
$T_1 = 724$ K
$T_2 = 1526$ K
$P_2 = ?$
$p_2 = [3.7 \times 1526] / 724 = 7.79$ atm

3.150.

1. Partial pressure (C)
2. Combined Gas Law (A)
3. Boyle’s Law (D)
4. Ideal Gas Constant (B)
5. Charles’ Law (E)
6. Ideal Gas Law (F)

3.151.

1. Diffusion: The tendency of molecules to move toward areas of higher concentration until the concentration is uniform throughout. (F)
2. Ideal Gas Constant: A term in the ideal gas law, which has the value 8.31 J/molK (T)
3. The volume occupied by one mole, n = 1, of substance is called the molar volume, Vmolar = V / n. (T)
4. P V = n R T, is called the ideal gas law or equation of state (T)
5. Boyle’s Law: states that for a given mass of gas at constant temperature, the volume of the gas varies inversely with volume (F)
6. Gay-Lussac’s Law: The pressure of a gas is directly proportional to the Kelvin temperature if the volume remains constant (T)
7. compressibility: measure of how much the volume of matter decreases under pressure (T)
8. Relationship between the volume (V) and the pressure (p) of a contained gas at constant temperature (T): when the pressure decreases, volume increases (T)
9. Charles' Law describes the proportional relationship between the pressure and volume of a gas (F – Boyle’s)
10. Dalton's law of partial pressures states that the volume of a gas is directly proportional to its temperature in kelvins if the pressure and the number of particles is constant. (F – Charles’)
11. Gay-Lussac's law: volume is dierectly proportional to temperature at constant pressure (F)

3.152.

Name of the Gas Law	Equation	Parameters that change	Parameters held constant
Boyles	$p_1 \times V_1 = p_2 \times V_2$	1. C	2. G
Gay-Lussac	3. A	4. p, T	V amount of gas
Charles	5. D	V, T	6. H
Combined	7. F	8. B	amount of gas

A) $p_1 \times T_2 = p_2 \times T_1$
B) p, V, T
C) p, V
D) $V_1 \times T_2 = V_2 \times T_1$
E) p, T
F) $p_1 \times V_1 \times T_2 = p_2 \times V_2 \times T_1$
G) T amount of gas
H) p amount of gas

3.153.

$T = 27 + 273 = 300$ K
$R = 118$ J / mol K
$p = 750\,000$ N/m^2
$\rho = p / R \cdot T$
$\rho = 750000 / (118 \times 300) = 21.186$ kg/m^3
$\gamma = \rho \times g = 21.186 \times 9.81 = 207.83$ N/m^3
$V = 1 / \rho = 1 / 21.186 = 0.0472$ m^3 / kg

3.154.

m = 1500 kg
V = 1189.5 dm^3 = 1.1895 m^3

a) $F=W=m \times a = 1500 \times 9.81 = 14715$ N
b) $\rho = m/V = 1500 / 1.1895 = 1261.03$ kg/m^3
c) $\gamma = W/V = 14715 / 1.1895 = 1237.07$ N/m^3 or $\gamma = \rho \times g = 1261.03 \times 9.81 = 1237.07$ N/m^3

3.155. B
3.156. C
3.157. A
3.158. A

3.159. true

3.160.
$K = - dp / (dV / V_0) = - (p_1 - p_0) / [(V_1 - V_0) / V_0]$

K = Bulk Modulus of Elasticity (Pa, N/m^2)

dp = differential change in pressure on the object (Pa, N/m^2)

dV = differential change in volume of the object (m^3)

V_0 = initial volume of the object (m^3)

p_0 = initial pressure (Pa, N/m^2)

p_1 = final pressure (Pa, N/m^2)

V_1 = final volume (m^3)

3.161. A

3.162. B

$K= -\Delta p/(\Delta V/V)$
K= - 1 / [(887-1200)/1200 = 3.846 MPa

3.163. B

3.164. D

σ= 0.0725 N/m
p= 0.04 N/cm^2= 0.04 x $10^4 N/m^2$
p= (4σ) / d
0.04 x 10^{4} = (4 x 0.0725) /d
d = 0.000725 m = 0.725 mm

3.165. A

3.166. A
3.167. C
3.168. A
3.169. B

3.170. C
m= 600 g = 0.6 kg
V = 200 cm^3= 0.0002 m^3
specific volume = 0.0002 / 0.6 = 3.33 x 10^{-4} m^3/kg

3.171. C

3.172.
$\Delta V = \alpha V \Delta t$
$\Delta V = 10^{-4} \times 2 \times 13 = 2.6 \times 10^{-3} m^3$

3.173.
A) true
B) false

3.174.
A) compressibility = change in pressure due to change in volume (false)
B) The bulk modulus is analogous to the modulus of elasticity for solids (true)
C) the volume modulus of elasticity known as the bulk modulus (true)
D) water has a minimum compressibility at about 50°C (true)
E) The compressibility is the reciprocal of the Bulk modulus (true)
F) liquid has higher compressibility than gas (false)
G) in the nature all the fluids are compressible (true)

4. Hydrostatics

4.1.

A) the branch of fluid mechanics (True)

B) categorized as a part of the fluid statics (True)

C) Some principles of hydrostatics have been known in an empirical and intuitive sense since medieval (False)

D) is the mechanics of fluids in static equilibrium (True)

4.2.

A) Takes up the shapeof the container

B) Flows easily

C) Flows easily

D) Changes volume to fill its container

E) Not easy to compress

F) Easy to compress

4.3.

A) Archimedes

B) physical law of buoyancy

C) Buoyancy

D) weight of displaced fluid

E) Heron's fountain

F) Blaise Pascal

G) principle of transmission of fluid-pressure

H) Atmospheric Pressure

I) mercury barometer

J) Daniel Bernoulli

K) increased fluid speed decreased internal pressure

4.4.

A fluid is said to be in hydrostatic equilibrium or hydrostatic balance when it is at rest, or when the flow velocity at each point is constant over time.

4.5. B

4.6. C

4.7. B

4.8. Calculate the mass.

Density: $\rho = 1270$ kg / m3

Volume: V = 200 cm3 = 0.0002 m3

Solution:

m = ρ x V = 1270 x 0.0002 = 0.54 kg

4.9.

3.2 g/cm3 = 3200 kg /m3

12.45 g /liter = 0.01245 g/cm3 = 12.45 kg/m3

2470 kg /m3 = 2470 g /liter = 2.47 g /cm3

4.10. B

4.11. A

4.12. D

4.13. C

4.14. B

4.15. B

4.16. C

4.17.B

4.18. A

4.19. A

4.20. B

4.21. B

4.22. An open tank contains water upto a depth of 3 m and above it an oil sp. gr. 0.9 for a depth of 1.5 m. Find the pressure intensity at the interface of two liquids!

h1= 3 m

h2= 1.5 m

ρ1= ρwater= 1000 kg/m3

ρ2= ρoil = 0.9 x 1000 = 900 kg/m3

p = ρ x g x h

p = ρ2 x g x h2 = 900 x 9.81 x 1.5 = 13243.5 N/m2

4.23.B

4.24. D

4.25.

p = ρ x g x h

P = 13600 x 9.81 x 0.780 = 104064.48 N/m2

4.26.

p = ρ x g x h

h = p / (ρx g)

h = 101475 / (1000 x 9.81) = 10.344 m

A comparable mercury barometer:

p= 101.475 kPa = 101475 Pa

ρmercury= 13600 kg /m3

h = ?

h = 101475 / (13600 x 9.81) = 0.7605 m

4.27.

A) increase

B) decrease

C) decrease

D) increase

E) decrease

F) decrease

G) decrease

H) increase

4.28

Specific Gravity = Relative Density dimensionless unit defined as the ratio of the density of a substance to the density of water

SG = ρsubstance / ρH2O

SG = Specific Gravity of the substance

ρsubstance = density of the fluid or substance [kg/m3]

ρH2O = density of water - normally at temperature 4 °C [1000 kg/m3]

0.75 = ρsubstance/ 1000

ρsubstance = 750 kg/m3

p = 750 x 9.81 x 10 = 73575 N/m2= 73.575 kN/m2

4.29.

6 : 1

660 mm : 110 mm

A2= [(d1)2x π] / 4 = [0.662x π] / 4 = 0.342 m2

A1= [(d2)2x π] / 4 = [0.112x π] / 4 = 0.009 m2

F1 / A1 = F2 / A2

F1 / 0.009 = (4200 x 9.81) / 0.342

F1= 1084.26 N

4.30.

a) ρrel = ρsubstrat /ρwater

ρsubstrat= m/V = 6200 / 7.4 = 837.84 kg/m3

ρrel= 837.84 / 1000 = 0.8378

b) p = ρ x g x h = 837.84 x 9.81 x 1.2 = 9863.05 Pa

c) pabs= p0+ (ρ x g x h) = 105+ 9863.05 = 109683.05 Pa

4.31. F = p x A

p = ρx g x h = 1025 x 9.81 x 8 = 80442 Pa

A = 10x 20 = 200 m2

F= 80442 x 200 = 16088400 N

4.32. B

4.33.

p0 = 1.01 x 105 Pa

h = 2.41 km = 2410 m

d = 55 cm = 0.55 m => r = d/2 = 0.275 m

ρocean water = 1027 kg/m3

p = p0 + ρgh

p = (1.01 x 105) + (1027 x 9.81 x 2410) = 2.438 x 107 N/m2 = 2.438 x 107 Pa

p = F / A = F/ (r2π)

2.438 x 107 = F / (0.2752 π)

F = 5.778 x 106 N

4.34. A

4.35. B

4.36. B

4.37. C

4.38. A

pB < pD < pC < pA

4.39. A

4.40.

A) false

B) true

C) false

D) false

E) true

4.41.

A) TRUE

B) TRUE

C) TRUE

D) FALSE

E) FALSE

F) TRUE

4.42. True or false?

A) True

B) False

C) True

D) True

E) False

F) True

G) False

H) True

I) False

J) False

K) False

4.43. B

4.44. C

4.45. D

4.46. B

4.47. D

4.48. B

4.49. C

4.50. C

4.51. A

4.52. B

4.53. D

4.54. A

4.55. D

4.56. B

$\rho = 800$ kg/m3

$h = 0.85$ m

$g = 9.81$ m/s2

$p = \rho \times g \times h = 800 \times 9.81 \times 0.85 = 6670.8$ N/m2

4.57.

p = 70 kPa = 70000 Pa

h= 2.35 m

γ= 12.34 kN/m3= 12340 N/m3

$p' = p + \gamma \cdot h = 70000 + (12340 \times 2.35) = 98999$ Pa = 98.999 KPa

4.58.

A:

$p_A = \rho_3 \times g \times h_3 = 800 \times 9.81 \times 2.5 = 19620$ Pa

$p_{abs} = p_0 + p_A = 100000 + 19620 = 119620$ Pa

B:

$p_B = \rho_2 \times g \times h_2 = 1000 \times 9.81 \times 1.2 = 11772$ Pa

$p_{abs} = p_0 + (\rho_3 \times g \times h_3) + (\rho_2 \times g \times h_2) = 100000 + (800 \times 9.81 \times 2.5) + (1000 \times 9.81 \times 1.2) = 131392$ Pa

C:

$p_C = \rho_1 \times g \times h_1 = 13600 \times 9.81 \times 0.6 = 80049.6$ Pa

$p_{abs} = p_0 + \rho_3 \times g \times h_3 + \rho_2 \times g \times h_2 + \rho_1 \times g \times h_1 = 100000 + (800 \times 9.81 \times 2.5) + (1000 \times 9.81 \times 1.2) + (13600 \times 9.81 \times 0.6) = 211441.6$ Pa

4.59. Pressure Variation in a Fluid at Rest C

4.60 Matching

1. buoyant force E
2. hydrostatic force on a plane surface B

3. Location of hydrostatic force on a plane C, D

4. pressure gradient in a stationary fluid A

4.61. pAB= ?

pAB= ρ x g x h = 1000 x 9.81 x 6 = 58860 Pa = 58.86 kPa

Convert the pressure to a force per length by multiplying by the width:

p = pAB x width

p = 58860 x 6 = 353160 Pa

We can write the equilibrium equation for gate AB

∑MB= FA x 4 – (353160 x 4 x 4/2) = 0

FA = 706320 N = 706.32 kN

5.Fluid Kinematics - 6. Continuity equation
5.1. A, C

5.2. Flow patterns can be visualized using:
A) timelines
B) pathlines
C) streaklines
D) streamlines

5.3. Definition of timeline
If a number of adjacent fluid particles in a flow field are marked at a given instant, they form a line in the fluid at that instant; this line is called a timeline.
5.4. Definition of pathline
A pathline is the path or trajectory traced out by a moving fluid particle.
5.5 Definition of streamlines
Streamlines are lines drawn in the flow field so that at a given instant they are tangent to the direction of flow at every point in the flow field.

5.6.
In a steady flow, pathlines, streaklines, and streamlines are identical lines in the flow field.
The difference between a fluid and a solid is, that stresses in a fluid are mostly generated by motion rather than by deflection.
Streamlines: they are tangent to the direction of flow at every point in the flow field.
In steady flow, the velocity at each point in the flow field remains constant with time.

The stress at a point is specified by the nine components, where σ has been used to denote a normal stress, and τ to denote a shear stress. Viscous flow can be laminar or turbulent.

5.7.

A1 : ………………………………….. hose ; ………………………………………. speed
A2: …………………………………… hose ; ………………………………………. speed
A1: wider hose, slower speed
A2: narrower hose, faster speed

5.8. Volumetric flow rate
Volume of fluid in element: V = A x L
Velocity of fluid: v = L / t
Volummetric flowrate: Q = V / t = (A x L) / t = A x v

5.9.
Solution:
d1 = 0.2 m => A1 = (d12π) / 4 = (0.22π) / 4 = 0.0314 m2
d2= 0.1 m => A2= (d22π) / 4 = (0.12π) / 4 = 0.00785 m2
Q1 = A1 x v1 = 0.0314 x 6 = 0.1884 m3/ s
Q1 = Q2 = 0.1884 m3/ s
v2 = Q2 /A2 = 0.1884 / 0.00785 = 24 m/s

5.10.
Volume flow in over: A1=A1 x V1 x Δt
Volume flow out over: A2= A2 x V2 x Δt
Mass in over: ρ x A1 x V1 x Δt
Mass out over: ρ x A2 x V2 x Δt
ρ x A1 x V1 = ρ x A2 x V2

5.11. B
Explanation: The continuity equation is only applicable to incompressible as well as compressible fluid.

5.12. C
Explanation: In majority of the fluid flow problems, flow is assumed to be steady.

5.13. A
Explanation: According to continuity equation,
ρ*A*v = constant

Hence, as density and area decreases velocity is bound to increase.

5.14. B
Explanation: Continuity equation is based on the the principle of conservation of mass.

5.15.

5.15. D
5.16. A
5.17. C
5.18. A
A1v1 + A2v2 = Av
d2v + d2v = D2v
D = d.
5.19. A
A1v1 + A2v2 = Av
d2v + d2v = Dv/2
d = D / 4.

6. Pressure and Fluid Statics
6.1.
Weight of the water column = Weight of the kerosene column
ρ x g x h1 x SG1 = ρ x g x h2 x SG2 = ρ x g x h3 x SG3
1000 x 9.81 x 15 x 1.0 = 1000 x 9.81 x h2 x 0.8 = 1000 x 9.81 x h3 x 1.62
h2= 18.75 m
h3= 9.26 m

6.2.
Area of the gate = 7 x 4.5 = 31.5 m2
h = P / (ρx g) = 225000 / (1000 x 9.81) = 22.93 m
F = ρ·g·x·A
x = 22.93 – 3.5 = 19.43 m
F = 1000 x 9.81 x 19.43 x 31.5 = 6004161.45 N = 6004.16 kN

6.3.
h = 17 m
ρ= 1030 kg/m3
p = ρ x g x h = 1030 x 9.81 x 17 = 171773.1 N/m2 [Pa]
The gauge pressure is the pressure above the normal atmospheric pressure => p = 171773.1 N/m2
The absolute pressure is: P abs= p0 + p = 101213 + 171773.1 = 272986.1 N/m2= 272.98 kN/m2

6.4.
Force on the dam= pressure of the water x Area
The area refers to the surface of the dam that come into direct contact with the water.
F= (density of water) x (acceleration of gravity) x (height of the water/2) x (width of the dam (x) height of the water)
$F = [\rho \times g \times (h/2)] \times (w \times h)$
F= [1000 x 9.81 x (35/2)] x (45x35) = 270388.12 kN

6.5. A
6.6.
$p_0 = 101325$ Pa
$p_{abs} = p_0 + \rho \times g \times h = 101325 + (1025 \times 9.81 \times 3) = 131490.75$ Pa = 131.49 kPa

6.7.
Headwater
Tailwater
Weight of the dam
Uplift

7. Environmental Impacts of Dams
7.1. C; 335 m
7.2. B
7.3. D
7.4. constant radius arch dam, variable radius arch dam, constant angle arch dam, double curvature arch dam

7.5. Emissions, Erosion and sedimentation, Earthquakes and landslides, Waste management, Forest cover, Wildlife

7.6. Reasons and Environmental Impacts

	REASONS	ENVIRONMENTAL IMPACTS
Colorado River Basin	Irrigation and Hydroelectricity	Prevented water form reaching the mouth of the Colorado River causing an inverse estuary.
Three Gorges Gam	Hydroelectricty and flood control	Greenhouse gas and mercury emission, erosion, sedimentation
Aral Sea Watershed	Irrigation for cotton	Receding sea leaves huge plains covered with salt and toxic chemicals
Flooding Risks in Bangladesh	Each year in Bangladesh around 18% of the country is flooded	Land destructruction, erosion, climate change
Aswan High Dam	Flood control	Erosion, waterlogging, soil salinity

7.7. D
7.8. C

7.9.
Water supply dam
Irrigation dams
Multipurpose dams
Flood control dams
Power dams

7.10.
WEIRS BARRAGES DAMS
fixed mobile embankment Concrete
Earth
Brickwork
Concrete Plain
Radial
Flap Earthfills
Rockfills gravity
Arch

8. Bernoulli's equation
8.1. B
8.2. A
8.3.
v2 = 2 x g x h
v2 = 2 x 9.81 x 4
v = 8.85 m/s

8.4.
p + [ρ · (v2/2)] + ρgz = constant

8.5.
p/ (ρ·g) + v2/ 2g + z = constant

8.6. B
Within a horizontal flow of fluid, points of higher fluid speed will have less pressure than points of slower fluid speed.

8.7.
Let point 1 be on the surface of the lake and point 2 be at the outlet of the hole in the dam. The pressure at each point is just atmospheric pressure, so p1 = p2 = p0
y1 – y2 = 1.7 m
v1 = 0
p1+ ½ ρ · v12 + ρ · g ·y1 = p2+ ½ ρ · v22 + ρ · g ·y2
2g (y1 – y2) = v22
v2 = 5.77 m/s

8.8. C
8.9. A

9. Flow in Pipes
9.1. A, E
9.2.
Sum of the Flows in = Sum of the Flows out
A1 x v1 = A2 x v2 + A3 x v3
A1= (0.12x π) / 4 = 0.00785 m2
A2= (0.032x π) / 4 = 0.000706 m2
A3= (0.052x π) / 4 = 0.00196 m2
Q1 = A1 x v1 = 0.00785 m3
Q2 = A2 x v2 = 0.001413 m3
Q3 = Q1 - Q2 = 0.006437 m3
v3 = Q3 / A3 = 3.284 m/s

9.3.
d1= 200 mm = 0.2 m
A1= (d12π) / 4 = (0.22π) / 4 = 0.0314 m2
Q1= 8.3 L/s = 8.3 dm3/s = 0.0083 m3/s
v1= Q1 / A1 = 0.0083 / 0.0314 = 0.26 m/s
d2= 300 mm = 0.3 m
A2= (d22π) / 4 = (0.32π) / 4 = 0.0706 m2
Q2= 8.8 L/s = 8.8 dm3/s = 0.0088 m3/s
v2= Q2 / A2 = 0.0088 / 0.0706 = 0.125 m/s
Q3 = Q1 + Q2 = 0.0083 m3/s + 0.0088 m3/s = 0.0171 m3/s
A3= (d32π) / 4 = (0.272π) / 4 = 0.057 m2
v3= Q3 / A3 = 0.0171 / 0.057 = 0.3 m/s

9.4.
d1= 130 mm = 0.13 m
A1= (d12π) / 4 = (0.132π) / 4 = 0.0132 m2
Q1 = A1 x v1 = 0.0132 x 1.2 = 0.0158 m3/s
d2= 160 mm = 0.16 m
A2= (d22π) / 4 = (0.162π) / 4 = 0.02 m2
Q2 = A2 x v2 = 0.02 x 0.9 = 0.018 m3/s
Q3= 7.1 L/s = 7.1 dm3/s = 0.0071 m3/s
A3= (d32π) / 4 = (0.142π) / 4 = 0.015 m2
v3= Q3 / A3 = 0.0071 / 0.015 = 0.473 m/s
d4 = 190 mm = 0.19 m
A4= (d42π) / 4 = (0.192π) / 4 = 0.028 m2
Q4 = Q1 + Q2 + Q3 = 0.0158 m3/s + 0.018 m3/s + 0.0071 m3/s = 0.0409 m3/s
v4= Q4 / A4 = 0.0409 / 0.028 = 1.46 m/s

10. Flow in Open Channels

10.1. Rectangular open channel for river - Variables

A = Flow cross-sectional area, determined normal (perpendicular) to the bottom surface
b = Channel bottom width
F = Froude number
g = acceleration due to gravity
k = unit conversion factor
n = Manning coefficient
P = Wetted perimeter
Q = Discharge or flow rate
R = Hydraulic radius of the flow cross-section
S = Slope of channel bottom or water surface
V = Average velocity of the water

10.2. B
10.3. A
10.4. C
10.5. C
10.6.
Q = 2 m3/s
Water Depth = y = 5 m
Width = b = 7 m
Area:
A = y x b = 5 x 7 = 35 m2
Wetted Perimeter, P:
P = 2y +b = 5+5+7 = 17 m
Hydraulic Radius, R:
R = A / P = 35/17 = 2.06 m
Velocity (v):
v = Q / A = 2 / 35 = 0.057 m/s

10.7. B
Width b: 4.5 [m]
Height h: 3.0 [m]
Arera: 13.5 [m2]
Wetted perimeter: 10.5 [m]
Hydraulic radius Rh: 1.2857 [m]

10.8. Calculate the angle of slope α and the angle of slope β and the Hydraulic Radius (R)!
Width b: 4.0 [m]
Height h: 5.0 [m]
Slope left: 1.0 [m]
Slope right: 2.0 [m]
Angle of slope α: 45.0°
Angle of slope β: 26.5651°

Width B: 19.0 [m]
Area: 57.5 [m2]
Wetted perimeter: 22.2514 [m]
Hydraulic Radius Rh: 2.5841 [m]

10.9. Calculate Width (B), Area (A), Wetted perimeter (P) and the Hydraulic radius (R)!
Width: B= 16.0 m
Area: A = 32.0 [m2]
Wetted perimeter: P = 17.8885 [m]
Hydraulic radius: R =1.7889 [m]

11. Environmental fluid mechanics problems for the 21st Century
11.1. C
11.2. D
11.3. A
11.4. A
11.5. B

11.6.

PHYSICAL	CHEMICAL	BIOLOGICAL
Heat	Salinity	Viruses
Color	Dissolved oxygen	Bacteria
Turbidity	Dissolved solids	
Suspended solids	Metals	

11.7. B
11.8. Forces in a Fluid Environment
A) buoyant
B) dynamic
11.9. A

11.10.
organic pollutants
pathogens
thermal pollution
radioactive pollutants
suspended solids and sediments
nutrients
11.11. T
11.12. A
11.13.
Salinity changes within the ocean also have a significant impact on the local density and thus local sea level, but have little effect on global average sea level change.

LITERATURE

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