

# CHAPTER 1

## FUNDAMENTAL PROPERTIES OF WATER

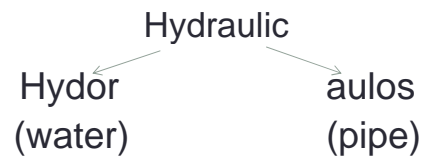
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### Introduction to the Hydraulics



The fundamentals of hydraulic engineering systems, therefore, involve the application of engineering principles and methods to the planning, control, transportation, conservation, and utilization of water

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## 1.1 The earth's atmosphere and atmospheric pressure

At sea level under normal conditions, atmospheric pressure

$$= 1.014 \times 10^5 \text{ Pa.}$$

$$= 1.014 \text{ bars}$$

$$= 760 \text{ mm Hg}$$

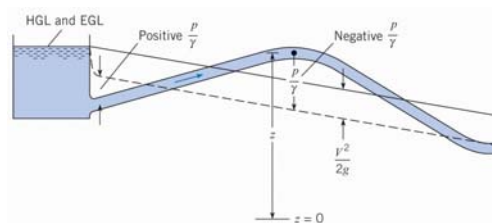
$$= 10.33 \text{ m H}_2\text{O}$$

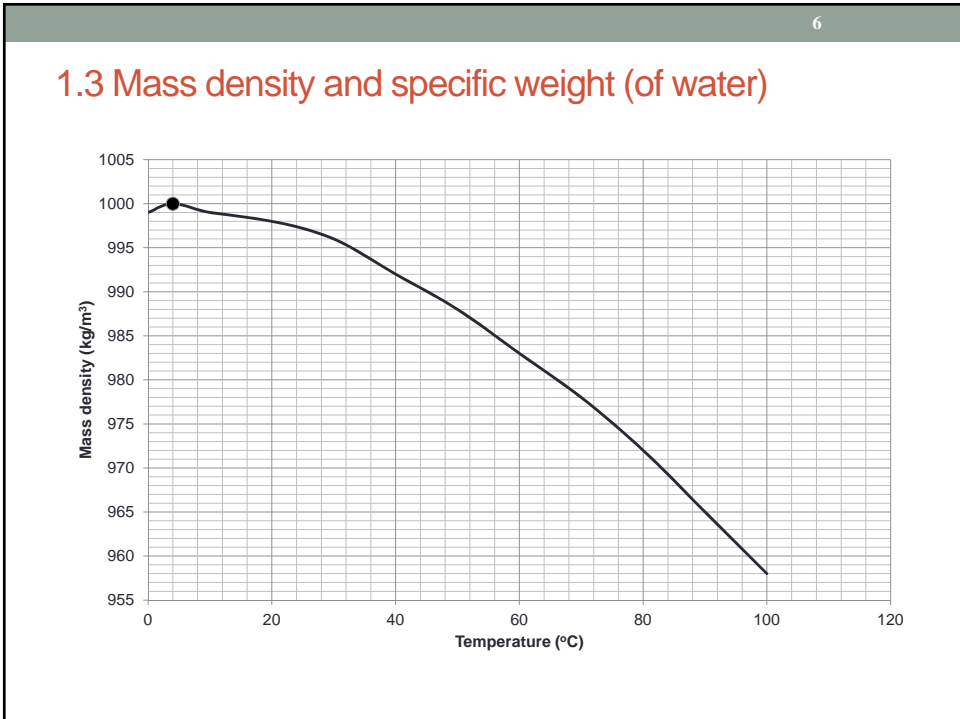
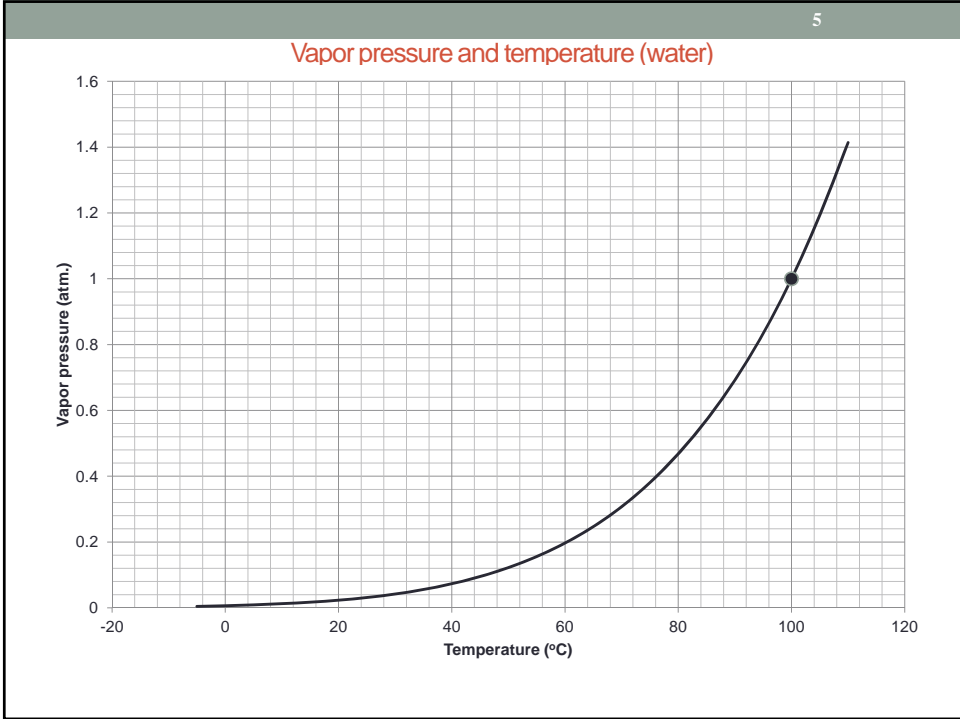
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## 1.2 The three phases of water

- Solid, liquid and gas (Ice, 'water' and vapor)
- **Latent energy:** The amount of energy required to change water from one phase to another
- **Specific heat** of a substance (heat required to raise the temperature of a substance by 1°C)
- **Vapor pressure:** the partial pressure exerted by the water vapor in the atmosphere.
- **Boiling point:** the temperature at which a liquid boils
- **Cavitation:** In a closed system (e.g. pipelines or pumps), water vaporizes rapidly in regions where the pressure drops below the vapor pressure.

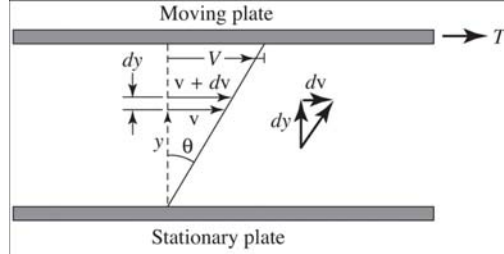
Tem °C	$p_v$ , kPa
0	0.611
5	0.872
10	1.23
20	2.34
30	4.25
40	7.38
50	12.35
<b>100</b>	<b>101.3</b>
200	1554



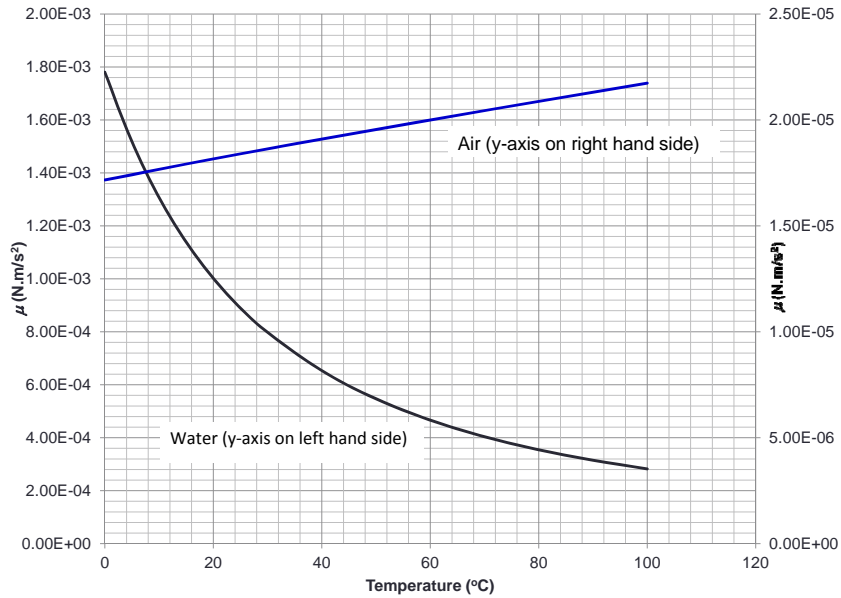


### 1.4 Viscosity of water

- Shear stress is proportional to rate of angular deformation
- Newton's law of viscosity
- Absolute viscosity
- 1 poise=0.1 N.s/m<sup>2</sup>
- Kinematic viscosity ( $\nu=\mu/\rho$ )

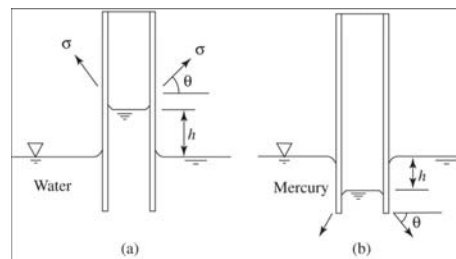
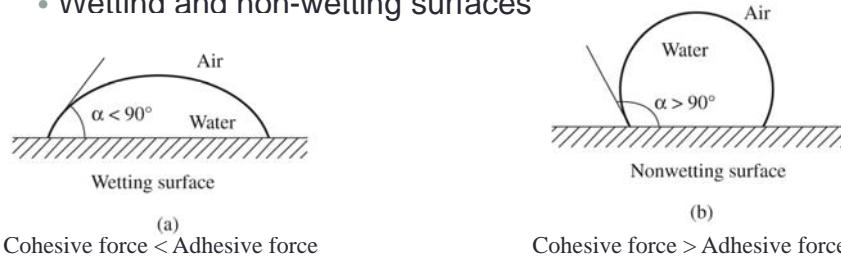


### Absolute viscosity and temperature



## 1.5 Surface tension and capillarity

- Cohesive and adhesive forces
- Wetting and non-wetting surfaces



## 1.6 Elasticity of water

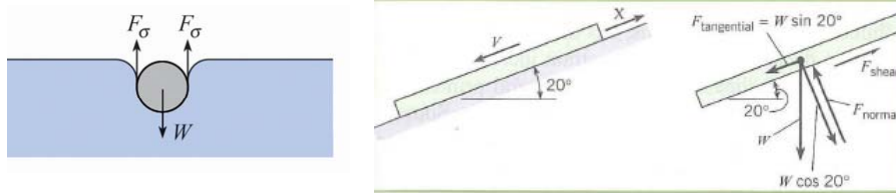
- Bulk modulus of elasticity (volume modulus of elasticity)

$$\Delta P = -E_b \frac{\Delta Vol}{Vol}$$

- Practical value of Bulk modulus of elasticity normally used =  $2.2 \text{ GN/m}^2$

## 1.7 Forces in a flow field

- Body forces (weight, buoyancy)
- Surface forces (hydrostatic force, shear force)
- Line forces (surface tension)



## CHAPTER 2

### WATER PRESSURE AND PRESSURE FORCES

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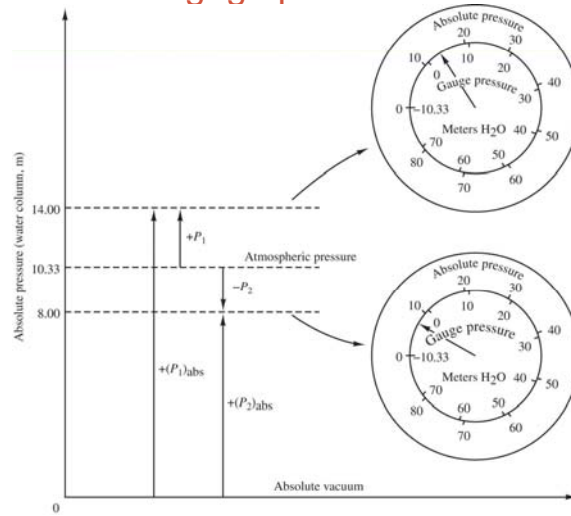
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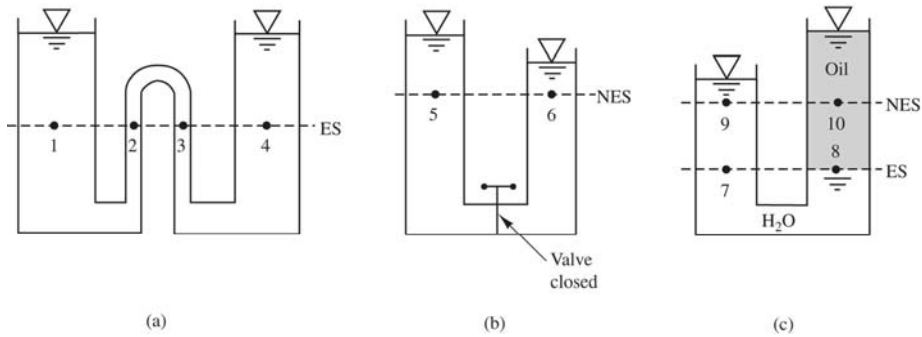
### 2.1 Free surface of water

### 2.2 Absolute and gage pressures

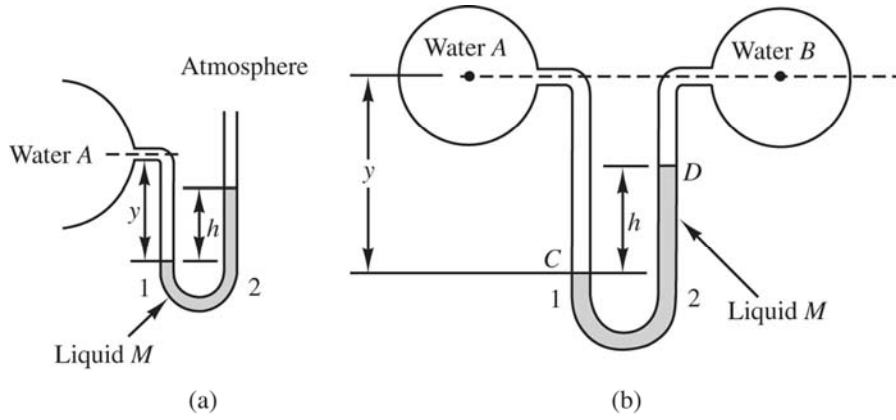


### 2.3 Surface of equal pressure

ES = equal pressure surface  
 NES = nonequal pressure surface



### 2.4 Manometers



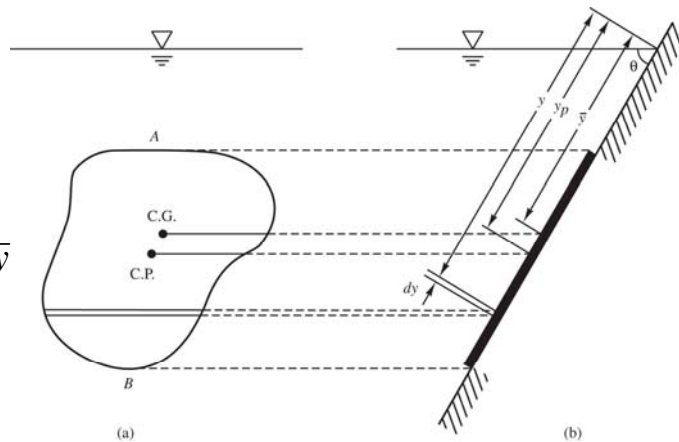
$$P_A = \gamma_M h - \gamma_W y$$

$$P_A - P_B = h(\gamma_M - \gamma_W)$$

### 2.5 Hydrostatic force on a flat surface

$$F = \bar{\gamma} h A$$

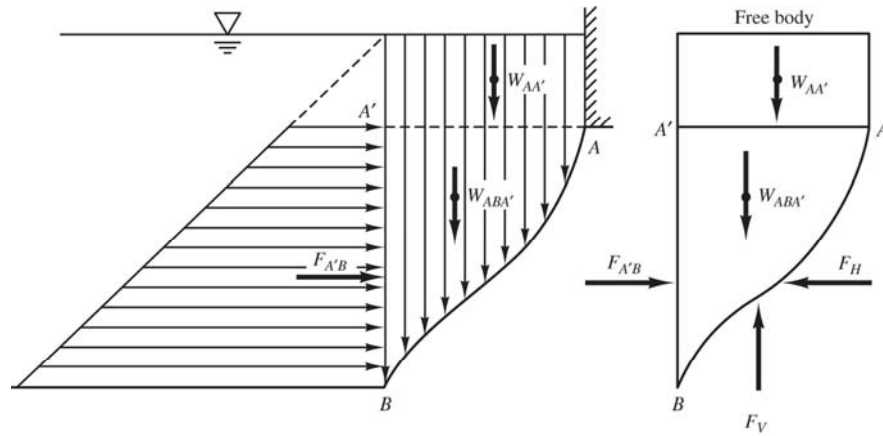
$$y_P = \frac{I_0}{A \bar{y}} + \bar{y}$$



See Table 2.1 for geometrical properties of various flat surfaces



## 2.6 Hydrostatic forces on curved surfaces



$$F_H = F_{A'B}$$

$$F_V = W_{AA'} + W_{ABA'}$$