Chapter 6 Pressure

- Pressure = force per unit area in a gas or liquid
- Stress = force per unit area in a solid
- Units of pressure: Table 6.1
  - 1 Pa (Pascal) = 1 N/m²
- Pressure under a column of liquid:  \( P = \rho gh \), Example 1
  - \( \rho \) = density of the liquid
  - \( g \) = acceleration due to gravity
  - \( h \) = height of the column
- Gauge pressure = pressure relative to atmospheric pressure
- Typical (gauge) pressures in the body: Table 6.2

6.1 Measurement of Pressure in the Body

- Manometer
  - Pressure is measured as the height of a column of liquid that produces a pressure equal to the pressure being measured
  - Example: U-shaped tube in Fig. 6.1
  - Fluids: mercury, water, or other low density fluids
- Sphygmomanometer: blood pressure measuring device
  - Mercury manometer: height of a column of mercury inside a glass tube
  - Aneroid type: movement of a needle connected to a sealed flexible container
- Pressure indicators of the body
  - Ears
  - Veins on the back of the hand

6.2 Pressure inside the Skull

- CSF (cerebrospinal fluid) in ventricles of the brain (Fig. 6.2)
  - Produced in the brain
  - Flows through the ventricles into the spinal column and eventually into the circulatory system
- Hydrocephalus (water head):
- Blocked ventricle at birth ⇒ CSF is trapped inside the skull ⇒ internal pressure increases ⇒ enlarged skull
- Detection by circumference measurement (normal value: 32 ~ 37 cm)
- Detection by transillumination
- Surgical installation of by-pass drainage system

6.3 Eye Pressure

- Aqueous and vitreous humors
  - Clear fluid in the eyeball
  - Transmits the light to the retina
  - Internal pressure of 12 ~ 23 mmHg maintain the eyeball in a fixed size and shape
  - The eye continuously produces aqueous humor and a drain system allows the surplus to escape
- Glaucoma
  - Partial blockage of the drain system ⇒ pressure increases ⇒ restricted blood supply to the retina tunnel vision or blindness
- Tonometer

6.4 Pressure in the Digestive System

- Digestive tract: Fig. 6.3
  - Opening through the body
  - Over 6 m
  - Closed at the lower end and has several restrictions
  - Valves and sphincters permit unidirectional flow of food
- Pressure in the gastrointestinal (GI) system
  - Greater than atmospheric pressure in most parts
  - Esophagus pressure is usually less than atmospheric pressure
  - Pressure in the stomach
    - Eating increases the pressure in the stomach slowly due to increased volume
    - Air swallowed during eating increases the pressure in the stomach ⇒ burping or belching
  - Pressure in the gut
Bacterial action generates gas (flatus) ⇒ increase gut pressure
Belts, girdles, flying, or swimming ⇒ affect gut pressure

- Pylorus: valve
  - Prevents the flow of food back into the stomach from the small intestine
  - Blockage in the small or large intestine ⇒ high pressure between the blockage and the pylorus ⇒ blockage of blood flow to critical organs ⇒ death
  - Treatment
    - Intubation: a hollow tube though the nose, stomach, and pylorus
    - Surgery in a pressure-controlled operating room

- Voluntary change of pressure in the digestive system: deep breath ⇒ close of the lung at the glottis (vocal folds) ⇒ contract the abdominal muscles

### 6.5 Pressure in the Skeleton

- Weight bearing bone joint
  - Highest pressure in the body
  - At knee joint: more than 10 atm while walking
- Joint lubrication: chapter 3
- Shape and size of bone are designed to reduce the pressure: Fig. 6.5

### 6.6 Pressure in the Urinary Bladder

- Urinary bladder
  - Accumulation of urine ⇒ increase the urinary bladder pressure
  - Pressure-volume curve of the bladder: Fig. 6.6
    - Volume ~ \( R^3 \)
    - Pressure ~ \( R^2 \)
    - Maximum volume before voiding is about 500 ml for adults
    - At about 30 cmH\(_2\)O, micturition reflex occurs ⇒ muscle contraction ⇒ pressure increase up to 150 cmH\(_2\)O ⇒
  - Voiding pressure
    - Normal: 20 ~ 40 cmH\(_2\)O
    - Prostatic obstruction: over 100 cmH\(_2\)O
- Urinary bladder pressure measurements
  - Catheter with a pressure sensor through the urinary passage (urethra)
  - Direct cystometry using a needle (Fig. 6.7) gives a function of the sphincters
Medical Physics

Chapter 6 Pressure

- Urinary incontinence
  - Coughing, laughing, straining
  - Pregnancy, stress

6.7 Pressure Effects in the Diving

6.8 Hyperbaric Oxygen Therapy (HOT)

- Homework
  - Review questions: #6, #10