Definitions

• **Electro – Kardio / Cardio – Gram**
  – Graphic record (gram) of electrical (electro) heart activity (cardio)
  – EKG
    • Germanic
  – ECG
    • Romantic

• **Lead**
  – Voltage measurement (not a physical probe)
  – Unipolar (PD between electrode & physical or virtual ground)
  – Bipolar (PD between two electrodes)

Einthoven’s Triangle

• **Electrodes**
  – RA, LA, LL
  – RL, C = reference

• **3 Bipolar Leads**
  – I, II, III

• **3 Unipolar Leads**
  – aVR, aVL, aVF

• Approximated by an EQUILATERAL triangle

SRC: PNP, p.408
Lead = Projection of Cardiac Vector

\[ V_I = V_M \hat{u}_I \]

\[ V_I = \text{Projection of } M \text{ onto } \hat{u}_I \]

\[ V_I = M \cdot \hat{u}_I = |M| \cos \theta \]

Y-axis of EKG
(X-axis = time)

Wilson’s Central Terminal

CT = Measured (direct) or Average of RA, LA & LL (indirect)
6-Lead EKG (5 Electrodes)

- Bipolar
  - Convention makes signal positive for cardiac vector pointed toward apex (LL) or left ventricle (LA)
  - Lead I
    - $V(\text{LA}) - V(\text{RA})$
  - Lead II
    - $V(\text{LL}) - V(\text{RA})$
  - Lead III
    - $V(\text{LL}) - V(\text{LA})$

- Unipolar
  - Reference is augmented version of Wilson’s Central Terminal
  - aVR
    - Augmented Voltage at Right arm
  - aVL
    - Augmented Voltage at Left arm
  - aVF
    - Augmented Voltage at left Foot

Augmented Unipolar Leads
(same direction – larger magnitude)

$VL = LA - \text{mean}(RA, LA, LL)$

$aVL = LA - \text{mean}(RA, LL)$
Limb Leads (Coronal Plane)

≈30° between lead vectors

12-Lead EKG

Precordial Leads (Transverse Plane)

≈15° between lead vectors
6-Lead EKG

- **P Wave**
  - Firing of SA node
  - Atrial depolarization
- **QRS Complex**
  - Firing of AV node
  - Ventricular depolarization
- **T Wave**
  - Ventricular repolarization

- Bandwidth ≈ 150Hz (American Heart Assoc.)

Electroencephalogram (EEG)

<table>
<thead>
<tr>
<th>Abilities</th>
<th>Thought Processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific Skills</td>
<td>Art &amp; Music Imagination</td>
</tr>
<tr>
<td>Number Skills</td>
<td>3-D Forms</td>
</tr>
<tr>
<td>Reasoning</td>
<td>Insight</td>
</tr>
<tr>
<td>Language</td>
<td>Left Hand</td>
</tr>
<tr>
<td>Right Hand</td>
<td>Cerebellum</td>
</tr>
</tbody>
</table>

Left Brain | Right Brain
Organs

Sensory           Motor

SRC: PNP, p.114, 116

EEG Electrodes

75 Electrodes
EEG Frequency Spectrum

- **Amplitude**
- **Frequency (Hz)**
- **Asleep**
- **Drowsy**
- **Relaxed (eyes closed)**

- **Frequency Bands**
  - **Δ** (Delta): 0-4 Hz
  - **θ** (Theta): 4-8 Hz
  - **α** (Alpha): 8-13 Hz
  - **β** (Beta): 13-30 Hz
  - **γ** (Gamma): 30+ Hz

- **Activity States**
  - Drowsy
  - Active Motion
  - Concentrating

Epileptic Seizure

- **Partial**
- **General**
Electromyogram (EMG)

- Muscle Cell Depolarization
- Excitation / Contraction Coupling

EMG Data Processing

Bandwidth ≈ 20 Hz

- Raw Data (Lifting Exercise)
- DC Offset Removed
- Rectified
- LP Filtered
- Integrated (Effort / Motion)

SRC: PNP, p.278