Constraints

- Something of the system of interest that restricts the way it can work
- Skeletal- anatomical range of motion, biomechanics
- Muscular- origin and insertion points
- Neural- groups of muscle fibres contract, central fatigue, pattern and organisation of networks
- Time- delay between information and task execution

Resting Membrane Potential

- Due to balance between chemical and electrical forces acting on ions
    - Chemical- preference for even concentrations of particles
    - Electrical- particles repel or attract based upon charge of ions between particles
- Resting membrane potential in a neuron is close to K+ equilibrium (-70 mV) since more permeable to K+ and more K+ inside the cell [negative because of 3 Na+ out and 2 K+ in]

Graded Potentials

- At dendrites (short distance)
- Mechanically or chemically gated
- Varies with stimulus
- Temporal summation

Action Potentials

- ✶ Axon hillock (long distance)
- ✶ Voltage gated
- ✶ Same strength
- ✶ Refractory period

Subthreshold Potentials

- Na+ channels open and depolarise post-synaptic membrane
- Graded potentials decrease in strength as it travels through cell body, below AP threshold
- Depolarising- EPSP Hyperpolarising- IPSP
- Spatial summation- simultaneous graded potentials at different locations of the cell body
- Temporal summation- simultaneous graded potentials from the same synapse at similar time

Suprathreshold Potentials (AP)

- Strong stimulus with larger EPSP: - 55 mV for action potential
- Rising phase (Na+ permeability), Falling phase (K+ permeability), Hyperpolarisation (K+ efflux)

Motor Unit Recruitment

- Contraction force can be varied by recruitment (changing number of motor units active) or rate coding (changing the firing rate of different motor units)
- Firing rate range from 5-50 Hz
- Small motor neurons have largest resistance, thus greatest voltage (V= I x R)
- Large motor neurons are recruited last
- Henneman's Size Principle- with same input small motor units recruited first (Type I slow oxidative), intermediate (Type IIa fast oxidative) and lastly large motor units (Type IIb fast glycolytic)

Open Loop Control System

- Pre-programmed (no change after commands sent)- inaccuracies, cannot account for disturbances
- Used when movement is fast and no time for feedback- fast

Closed Loop Control System

- Uses feedback to compare intended and actual outcome
- Reactive, sensitive to time, can cause overshoot and oscillation if movement is quick

Feedback and Feedforward

- Dropping a shotput into hands with eyes closed
    - Feedback -> hand extends then flexes (closed loop)
- Dropping a shotput into hands with eyes opened
    - Feedforward -> eyes perceive ball and arm tenses (open loop)

Muscle Spindles- Mechanoreceptors (Intrafusal Fibres)

- Provide information about muscle length and velocity of stretch
- Small, elongated structure scattered among and parallel to the contractile extrafusal fibres
- Particularly dense in intrinsic hand and neck muscles

Muscle Spindle Innervation

Sensory

- Group Ia (primary) – velocity and length information (static and dynamic)
    - Large diameter afferent enters capsule and branches
    - Terminals wrap around fibre, ending on Bag 1 and 2 and nuclear chain fibres
- Group II (secondary) – length sensors (static)
    - Smaller afferents enter capsule and branch
    - Terminals on one end of Bag 2 and chain fibres

Motor

- Gamma motor neurons (fusimotor neurons) alter sensitivity to stretch but not force
- Gamma static innervates nuclear chain fibres and Bag 2 fibres
    - Discharge improves length sensitivity of spindle to respond more even though muscle is at same length (increase resting discharge)
- Gamma dynamic innervates Bag 1 fibres
    - Discharge improve dynamic (velocity) sensitivity