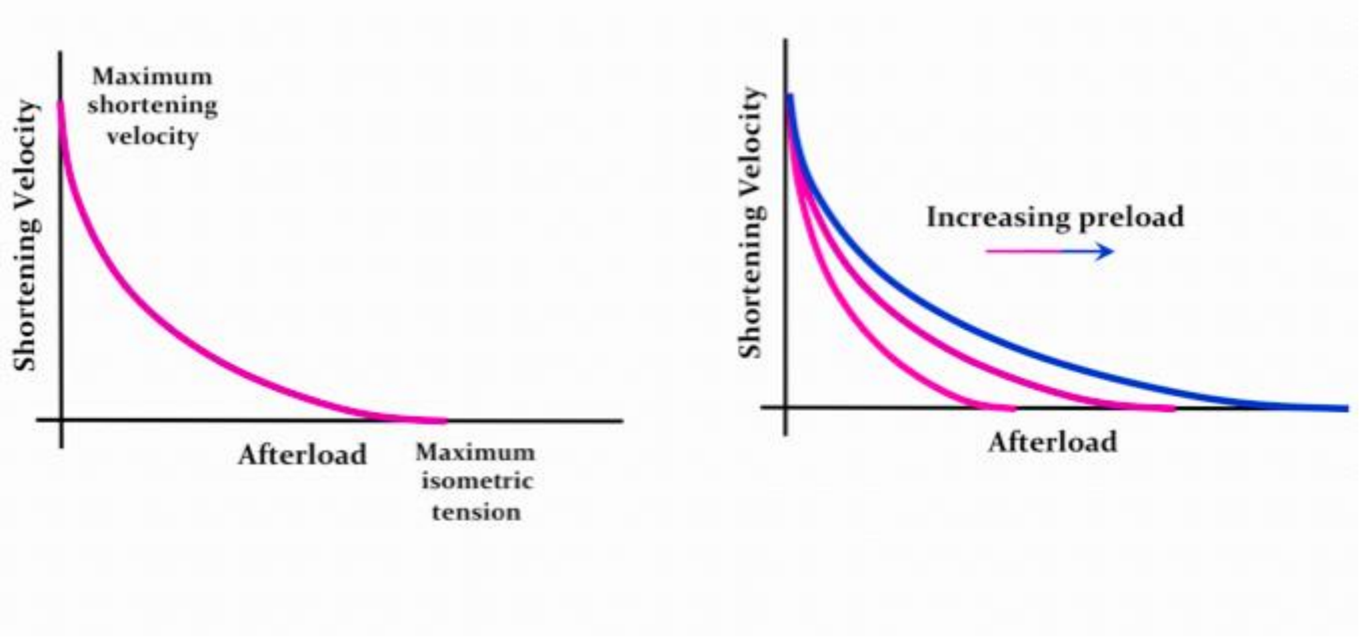
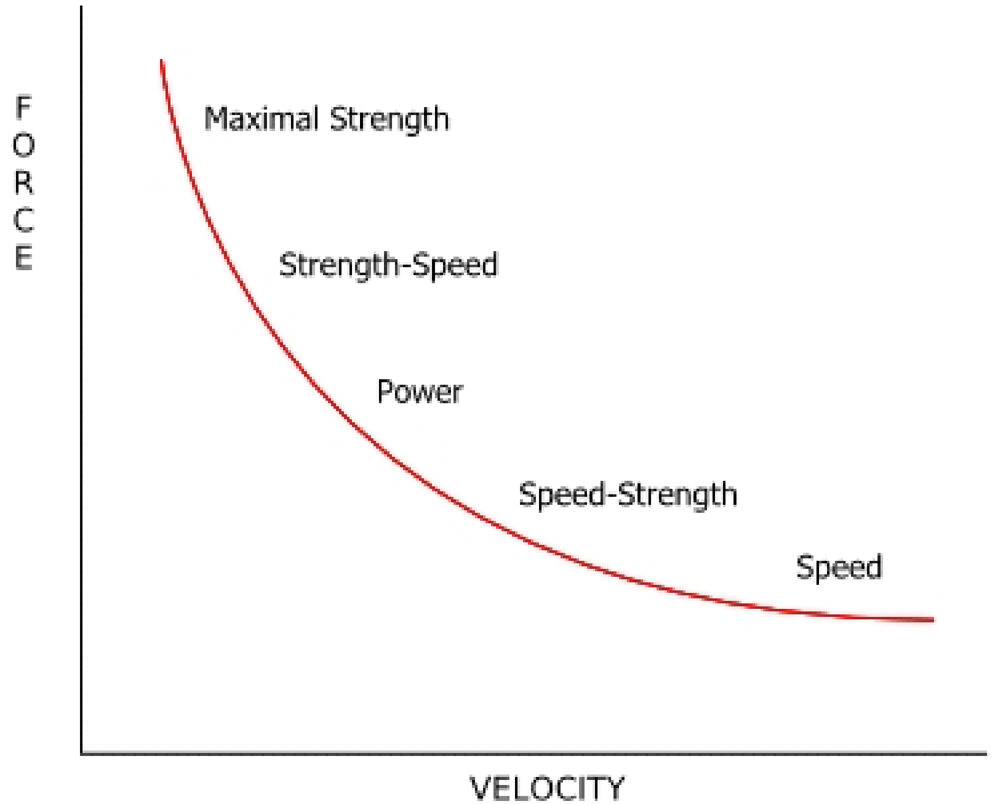
BE172 Week 3: Skeletal Muscle Force-Velocity Relation

Muscle 1 summary:
- Dissection, force measurement, muscle viability
- Active and passive force are a function of muscle (sarcomere) length

This week:
- Active force developed by a muscle is also a function of contractile velocity
- Well-documented property of skeletal muscle

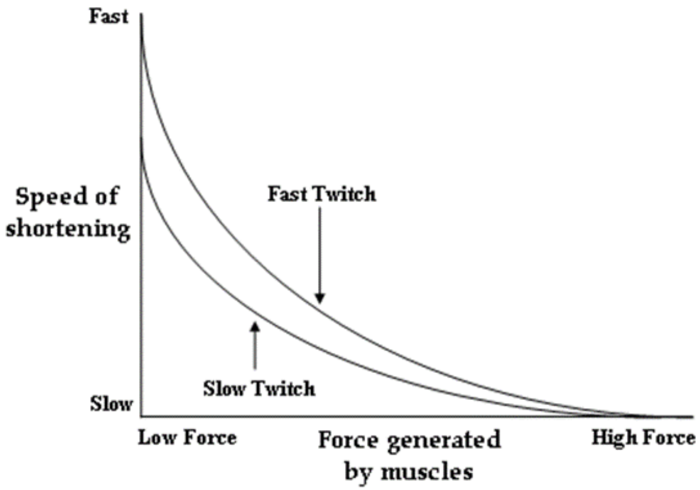


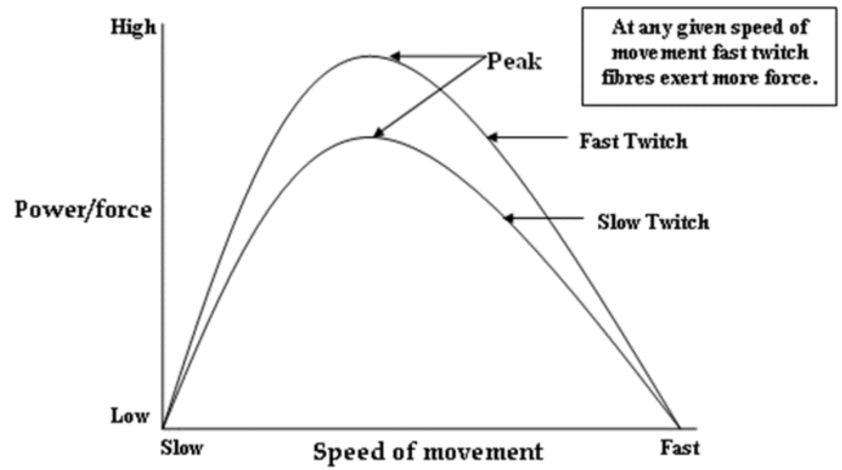
Force Velocity Implications



Trade-off between speed and strength

Shape of the force-velocity curve

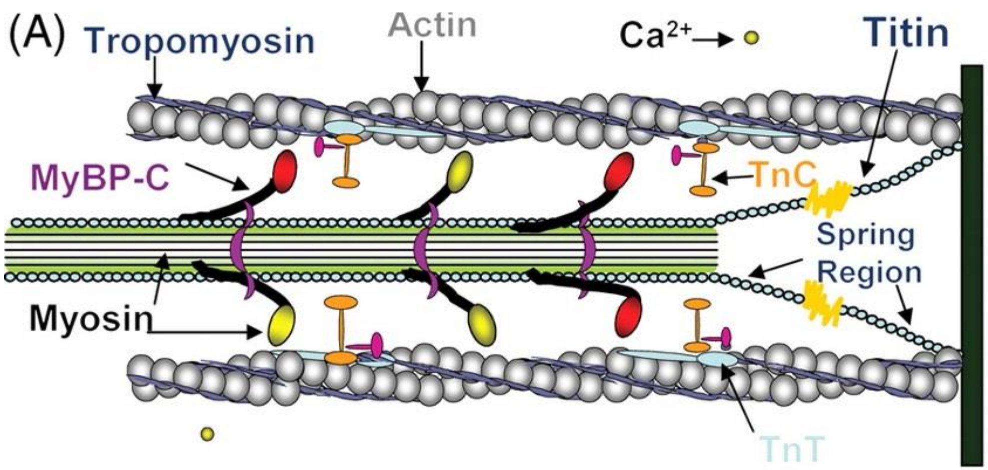




- A. V. Hill first described the curve as hyperbolic
- Mathematical form: $(F + \alpha)(V + \beta) = (F_o + \alpha)\beta$
  F = force, V = velocity, F_o = isometric force, α, β = constants

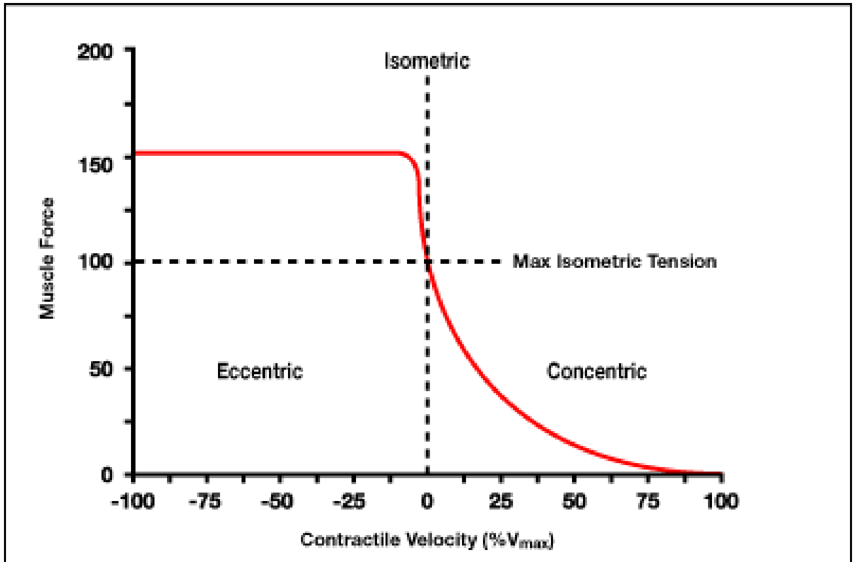
- Inverse relation between force and velocity
- Power is small when force or velocity are small
- F-V and Power curves can change with muscle type

Molecular basis of the force-velocity relationship



- At higher velocities, fewer cross bridges are able to form and generate force, this active force decreases with velocity of contraction
- More difficult for the myosin heads to attach onto the active sites on actin at higher velocities

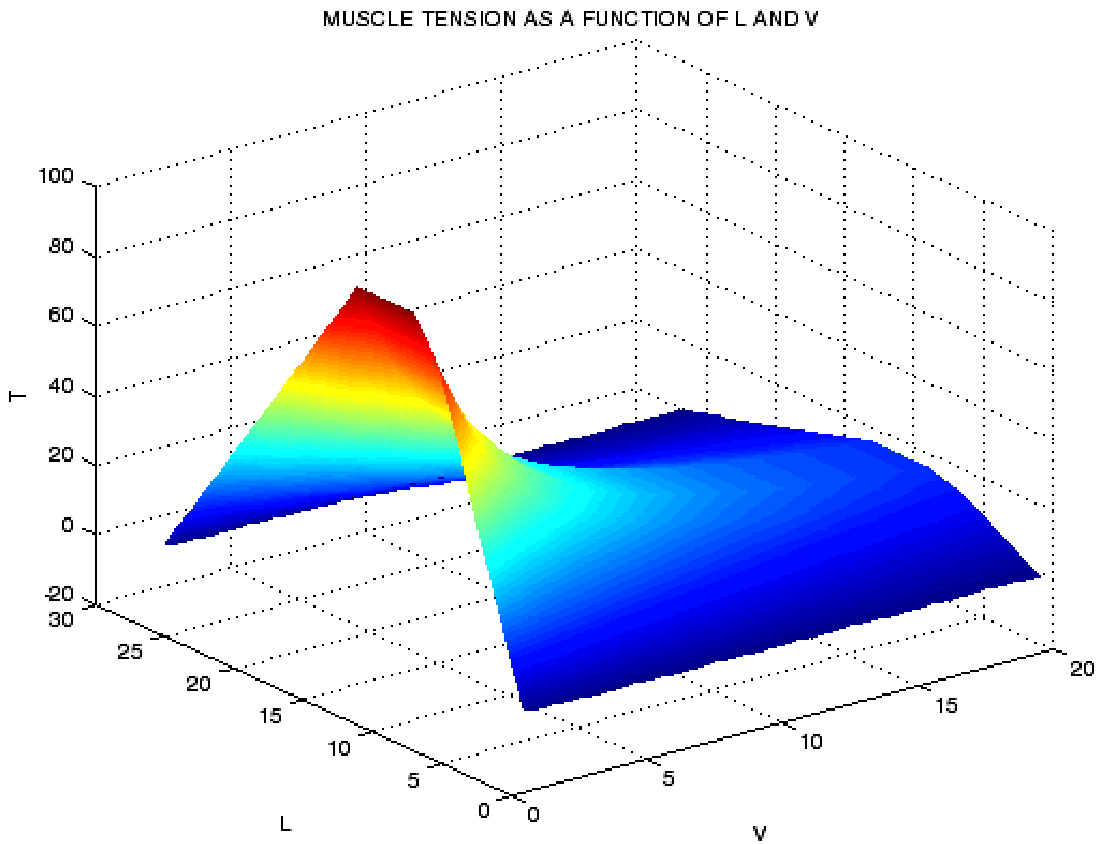
Can also have negative velocity of shortening



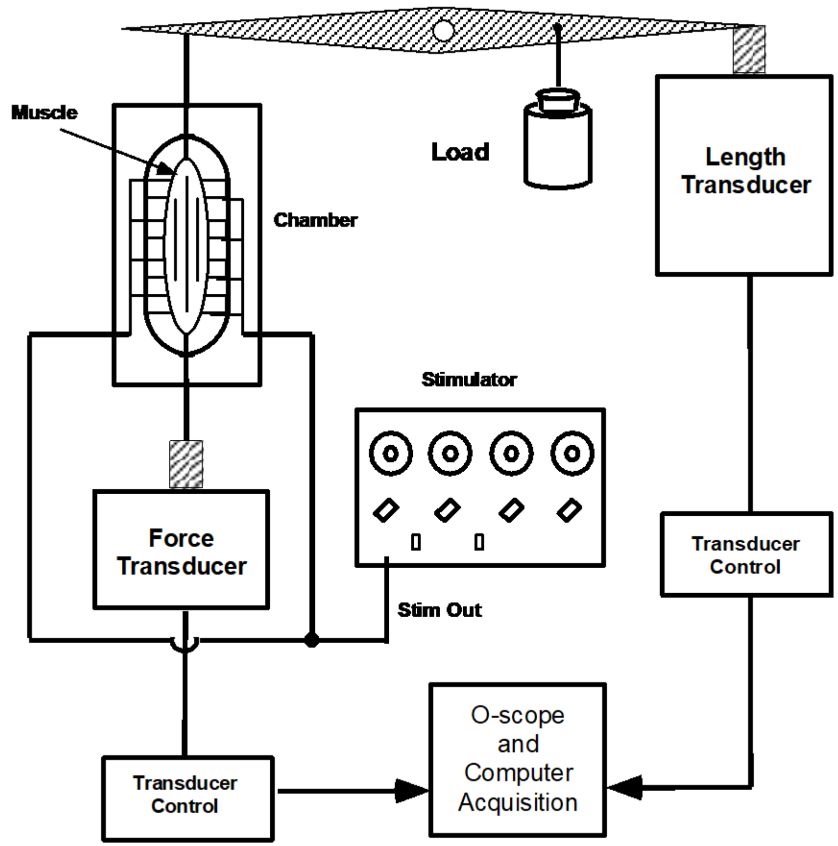
Muscle Force-Velocity Curve

- Eccentric contraction: muscle develops force, but is being stretched
- Resistive motions during uniform muscle movements use eccentric contractions
- Combinations of shortening and stretching can produce smooth motions

Combine force-displacement and force-velocity

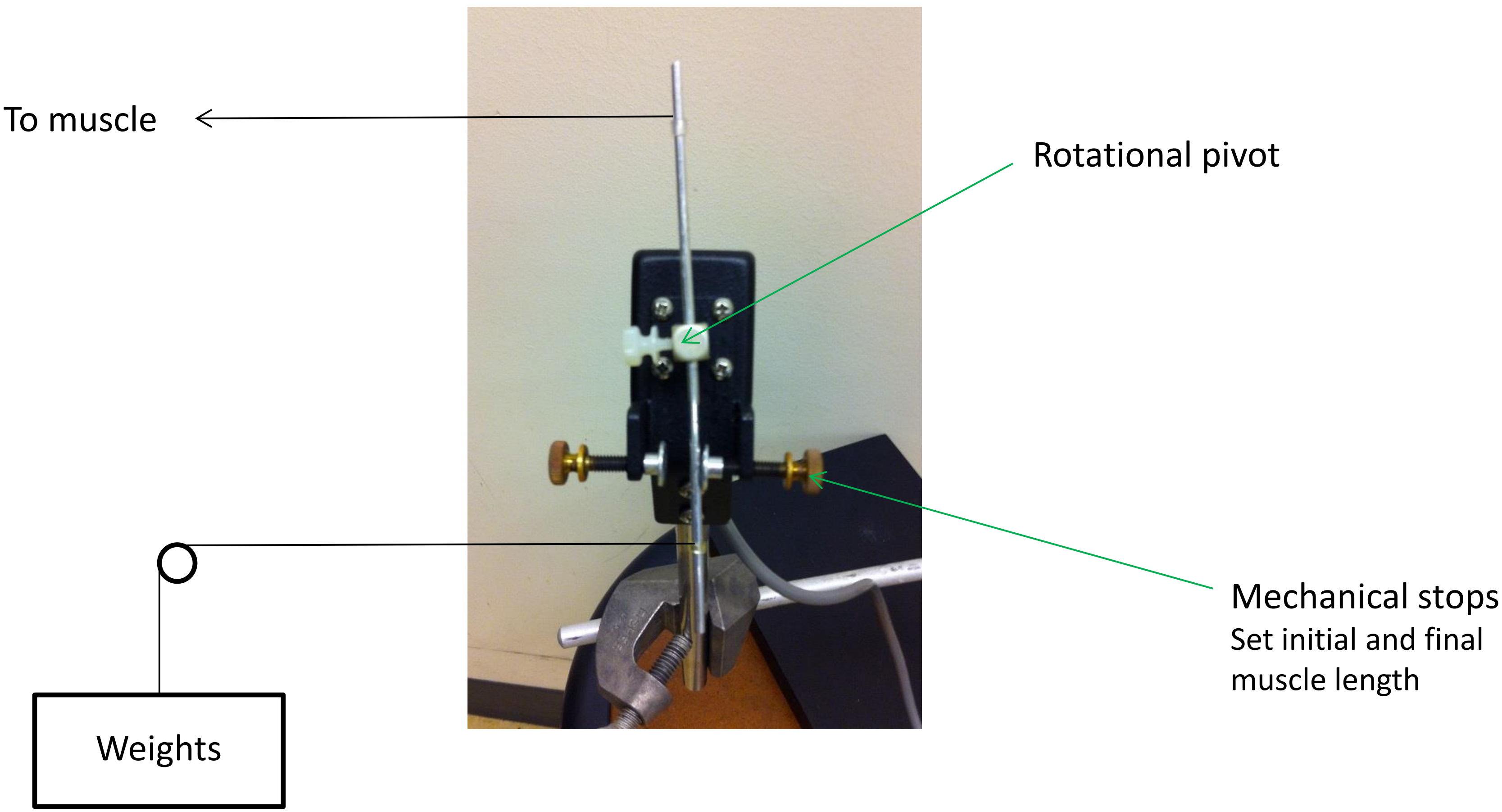


Experimental Setup and Measurement



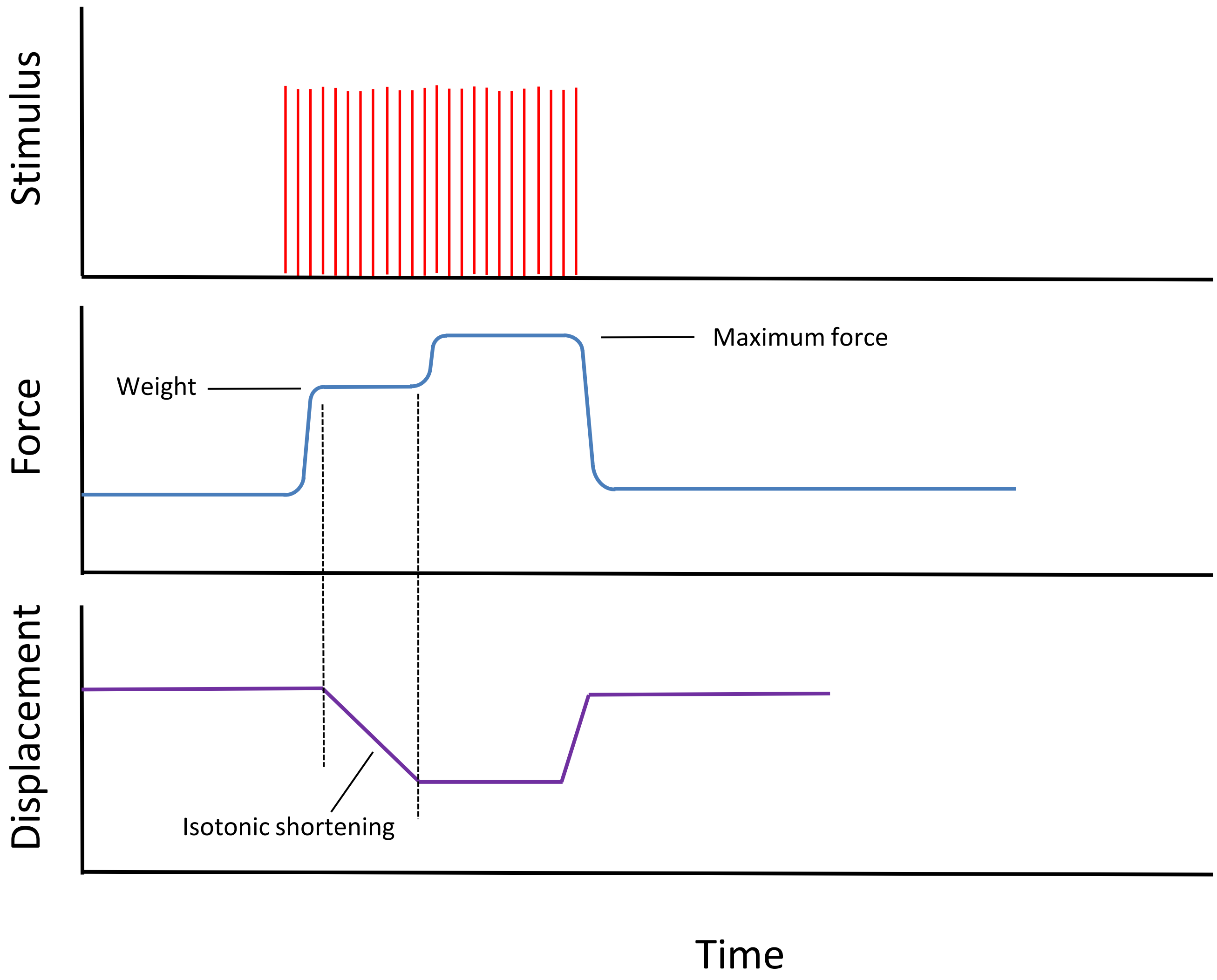
- Use computer this week to record time-course of contraction
- Measure force and displacement during isotonic shortening

Isotonic “displacement” gauge

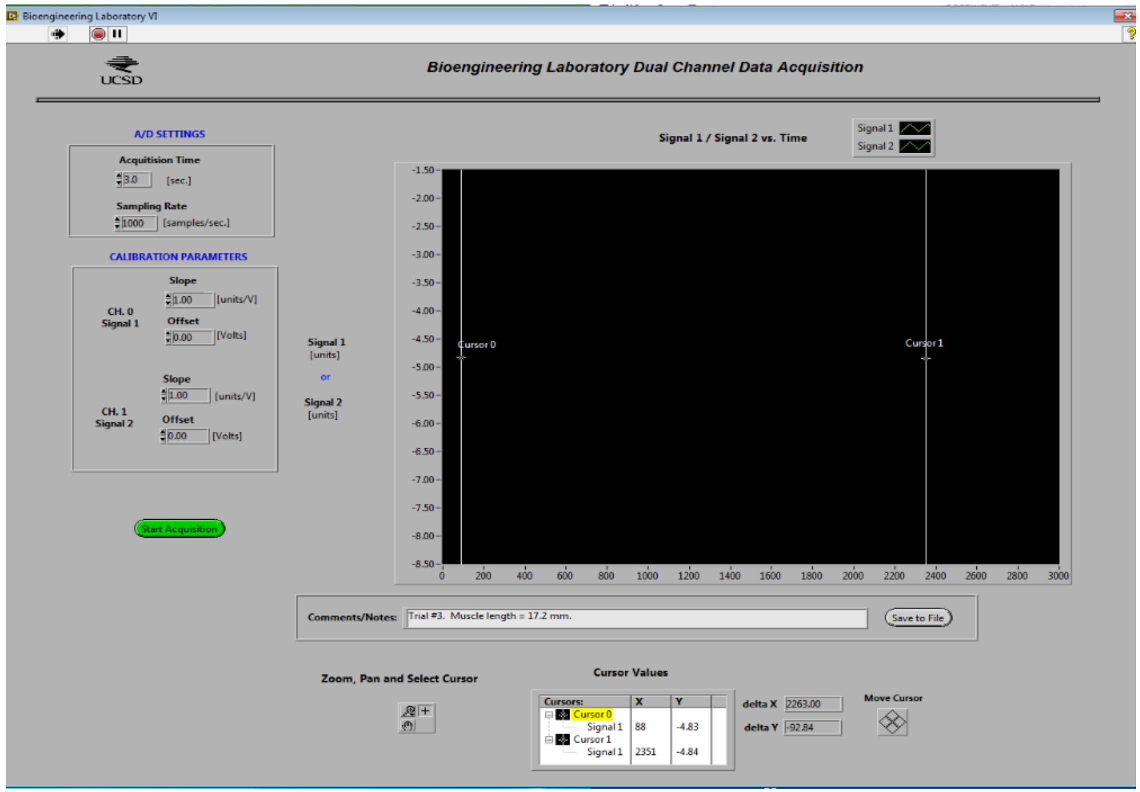


- Rotational gauge approximates linear displacement
- Velocity from displacement output (offset will not affect velocity calculation)

Tetanic contraction (50-60Hz) against a prescribed weight (afterload) will produce a single F-V point

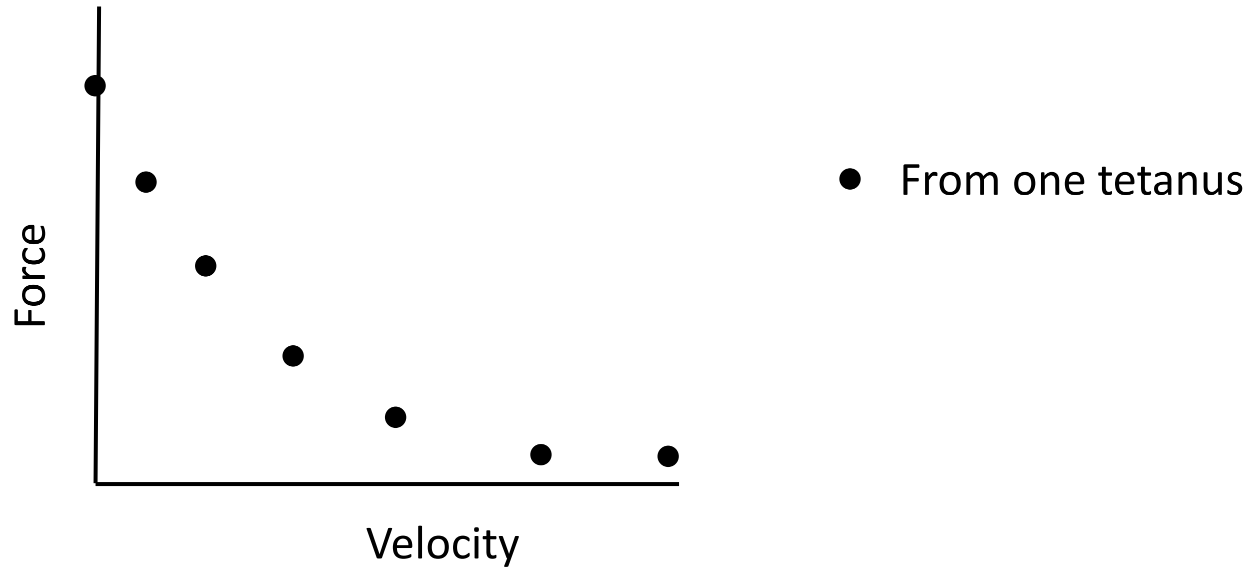


Use computer with Labview for recording data



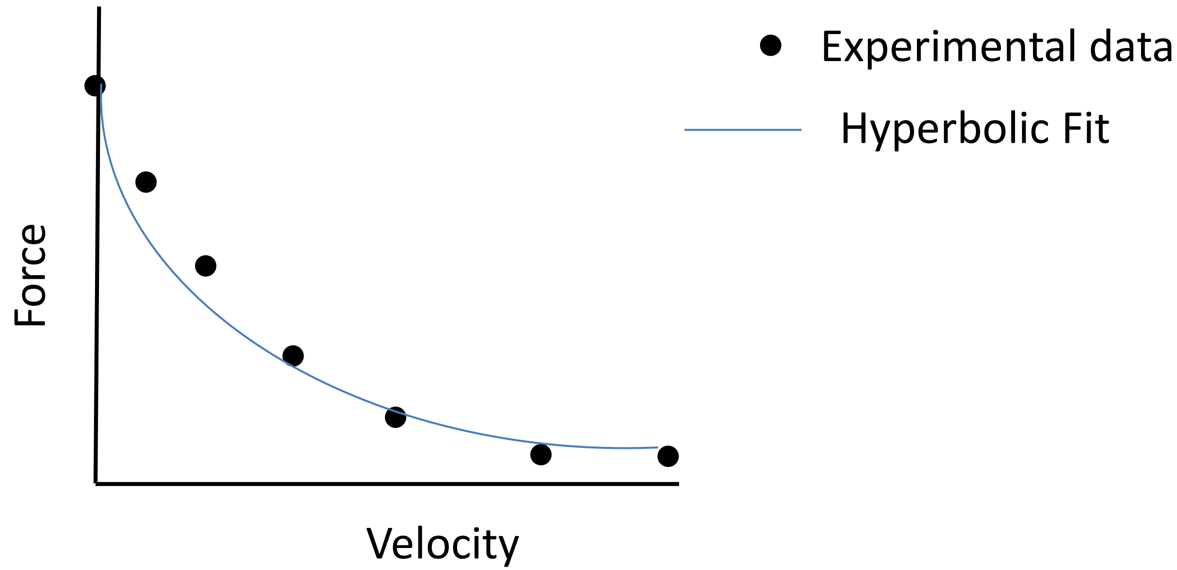
- Download VI, save in your AD account
- Enter calibration factors for force and velocity
- Adjust acquisition time as needed
- Use cursor functions to record rough values of force and velocity….just in case!
- Save each data file with the Save File button

Combine F-V data points to produce full F-V curve



- 6-8 points as usual for a non-linear curve
- 2 minute drill….don’t use all of the ATP on the first contraction!
- Save full contraction curve on computer, estimate F-V values later
- Do high velocity (low force) curves last: possible muscle damage

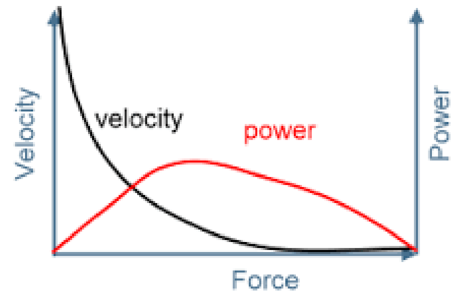
Curve fit to estimate Hill's equation



- Can use SigmaPlot on the Lab computers to fit the curve (or any other curve fitting method)
- Estimate the constants in Hill's equation for your muscle

Week 3 Experiment and data

- Set-up and calibrate both force and displacement gauges
- Same muscle dissection as last week (avoid damaging muscle, tight knots!)
- No sarcomeres this week, use muscle length
- Computer for data acquisition with LabVIEW. Keep o-scope connected as a backup
- Check each recording and data file (each tetanic contraction with shortening)
- 2-minute drill between tetanic contractions to conserve stored ATP energy
- Take data files with you when you leave the room; TA can sign one page or calibration pages
- Re-plot data to estimate force/velocity points for curve



Muscle Power = Force x Velocity