Welcome to 16.90 iSession ...

Instructor: Turn on Webex, and distribute MuddyCards ...

Students: Please LOG OUT from your Facebook, Twitter, Google+, Foursquare, Email, Messenger, ...etc... ...etc... ...etc...
Review and Reading recap

- Local accuracy
  \[ I \sim O(\Delta t^2) \]

- Global accuracy
  \[ |u(1) - v(1)| \sim O(\Delta t^2) \]

- Zero-stability
  \[ \frac{du}{dt} = 0 \]

- Eigenvalue stability
  \[ \frac{du}{dt} = \lambda u \]
• **Problem**: Ballistic trajectory prediction.

• Mathematically modeling (derive ODEs).

• Numerical solution: forward Euler.

• Numerical solution: midpoint rule.

\[ v^{n+1} = -4v^n + 5v^{n-1} + 4 \Delta t f(v^n) + 2 \Delta t f(v^{n-1}) \]

• Accuracy, stability and convergence.
Balistic trajectory prediction

- The first “real” computer, ENIAC (1946), was designed to perform numerical simulation and help engineers solve problems in ballistics.
Balistic trajectory prediction

- A motor fires a **3kg, 10cm** diameter, **spherical** cannonball, at **sea level**, in **standard atmosphere**.
- Given initial velocity, predict point of impact.
What are the physical processes?

A motor fires a 3kg, 10cm diameter, spherical cannonball, at sea level, in standard atmosphere.

Given initial velocity, predict point of impact.

**Gravity**: standard gravity coefficient 9.807.

**Aerodynamic drag**:
- Cannonball fired at subsonic speed of 150 m/s.
- Subsonic *Cd* of sphere 0.1-0.5 depending on the Reynolds number. We use *Cd* = 0.5.
- Air density 1.225 kg/m³ at sea level.

Derive the equations; compute all coefficients.