Exponential Loading

- $W(t) = W_e e^{\beta t}$
- $W_e = 1625$ kg/d
- $\beta = 0.04558$ /yr
Sinusoidal Loading

W(t) = W-bar + W_a \sin(\omega t - \theta)

- W-bar = 500,000 kg/yr
- W_a = 250,000 kg/yr
- T_p = \frac{2\pi}{\omega} = 1 yr
- phase shift, \theta = 0.5\pi

\phi(\omega) = \arctan\left(\frac{\omega}{\lambda}\right)

\[ c_p = \frac{W}{V\lambda}(1 - e^{-\lambda t}) + \frac{W_a}{V\sqrt{\lambda^2 + \omega^2}} \sin(\omega t - \theta - \phi(\omega)) \]

\[ -\frac{W}{V\sqrt{\lambda^2 + \omega^2}} \sin(-\theta - \phi(\omega)) \exp(-\lambda t) \]
Example (similar to: 11.1 from Reckhow & Chapra)
- Green Lake & Happy Valley
  - Hydraulic Parameters
    - Q=2x10^6 m^3/yr, V=1.1x10^9 m^3, A_s=10x10^6 m^2, H=10m
  - Decay: k=1.05/yr
  - Loading
    - local WWTP: 0.115x10^4 g/capita/yr, 20,000 people (long term, but at t=0, WW is pumped to regional plant)
    - new paper mill: 50x10^6 g/yr
    - new cattle feed lot: 150 animals, increasing by 100 cattle each year, 0.1x10^6 g/animal
    - New scenario: regional WWTP cannot accept new WW, town of Happy Valley is growing exponentially at 0.3/yr
    - New canning plant: annual cycle, avg=30x10^6 g/yr
      - max on Oct 1; min on Apr 1 (half of average)
Summation of Loading

- Cattle Feed Lot
- WWTP
- Canning plant
- Paper Mill
- Decay of Co

WWTP: diurnal variations
- Figures 1.6 a & b, from Thomann & Mueller
WWTP: weekly variations

- Figure 1.6 c, from Thomann & Mueller

WWTP: Seasonal Variations

- Figure 1.6 d, from Thomann & Mueller
Next: Cultural Eutrophication

- Many correlated WQ problems
  - Floating mats of algae
  - Low DO
  - High P?

To next lecture