

Chapter 8: 2 lectures

LRL

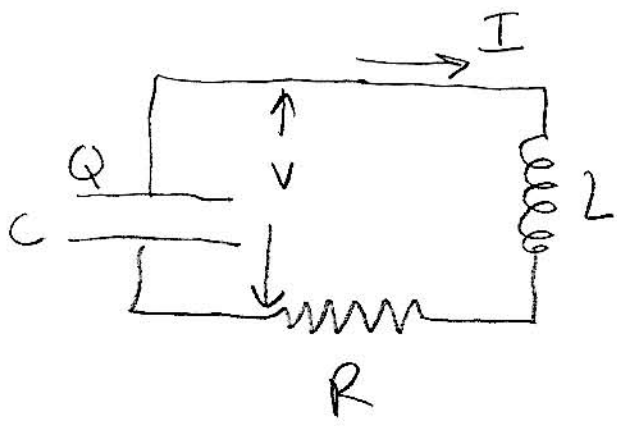
F: 11-12

Chapter 9: 2 lectures

EM waves.

Phelps 3505

TA: Colin Shepherd



← makes Q decrease.

$$I = - \frac{dQ}{dt}$$

$$Q = CV$$

$$V - L \frac{dI}{dt} = IR$$

get these into one equation...
choose V as variable.

$$I = - \frac{dQ}{dt} = -C \frac{dV}{dt}$$

$$V - L \frac{dI}{dt} = V + LC \frac{d^2V}{dt^2} = IR = -RC \frac{dV}{dt}$$

$$V + RC \frac{dV}{dt} + LC \frac{d^2V}{dt^2} = 0$$

looks like Damped S.H.O.

$$V = A e^{i\beta t} \quad (\text{Purcell: } A e^{-\alpha t} \cos \omega t)$$

(really, $V = \text{Re}(A e^{i\beta t})$)

$$A e^{i\beta t} + RCA(i\beta) e^{i\beta t} - ALC\beta^2 e^{i\beta t} = 0$$

$$1 + i\beta RC - \beta^2 LC = 0$$

$$a\beta^2 + b\beta + c = 0$$

$$\beta = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$a = -LC$$

$$b = iRC$$

$$c = 1$$

$$b^2 - 4ac = (iRC)^2 - 4 \cdot (-LC) \cdot 1$$

$$= 4LC - R^2C^2$$

$$\beta = \frac{-iRC \pm \sqrt{4LC - R^2C^2}}{2 \cdot (-LC)}$$

$$\beta = +i \cdot \frac{R}{2L} \mp \sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}$$

$$i\beta_{\mp} = -\frac{R}{2L} \mp i \sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}$$

$e^{i\beta t}$ has
damping

$$\omega \equiv \sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}$$

R small,
 ω real

$$\frac{1}{LC} - \frac{R^2}{4L^2} > 0$$

$$R < 2\sqrt{\frac{L}{C}}$$

otherwise, overdamped

$$V(t) = e^{-\frac{R}{2L}t} [V_+ e^{i\omega t} + V_- e^{-i\omega t}]$$

given $V(0)$, $V'(0)$, can solve for V_+ and V_- , might be complex.

$$\begin{aligned} V_+ e^{i\omega t} + V_- e^{-i\omega t} &= \frac{1}{2}(V_+ + V_-)(e^{i\omega t} + e^{-i\omega t}) \\ &\quad + \frac{1}{2}(V_+ - V_-)(e^{i\omega t} - e^{-i\omega t}) \\ &= (V_+ + V_-) \cos(\omega t) + i(V_+ - V_-) \sin(\omega t) \\ &\approx \underbrace{\text{Real part}}_{\text{gets } V(0)} \quad \approx \underbrace{\text{Imaginary part}}_{\text{gets } V'(0)} \end{aligned}$$

equivalent to Purcell (11).

$$V(t) = e^{-\frac{R}{2L}t} (A \cos(\omega t) + B \sin(\omega t))$$

$$A = \text{Re}(V_+ + V_-) \quad B = -\text{Im}(V_+ - V_-)$$

Suppose it is all $\cos(\omega t)$

