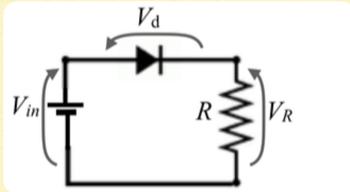
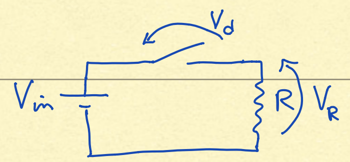
Phys 2610 (2019) Prelab 5 solutions



a) For the circuit of Fig. 3, and assuming an ideal diode with $V_t = 0.6$ V, what are the potential differences across the diode V_d and across the resistor V_R as the input bias voltage V_{in} is varied from 0 to 10 Volts? Draw the equivalent circuits to help you work this out, and draw sketches of V_d vs V_{in} and V_R vs V_{in}.

For $V_{in} < V_t$,

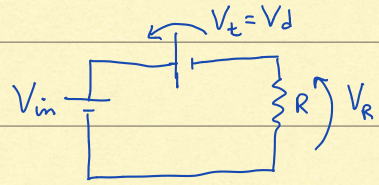


(eq't cct)

$V_d = V_{in}$

$V_R = 0$

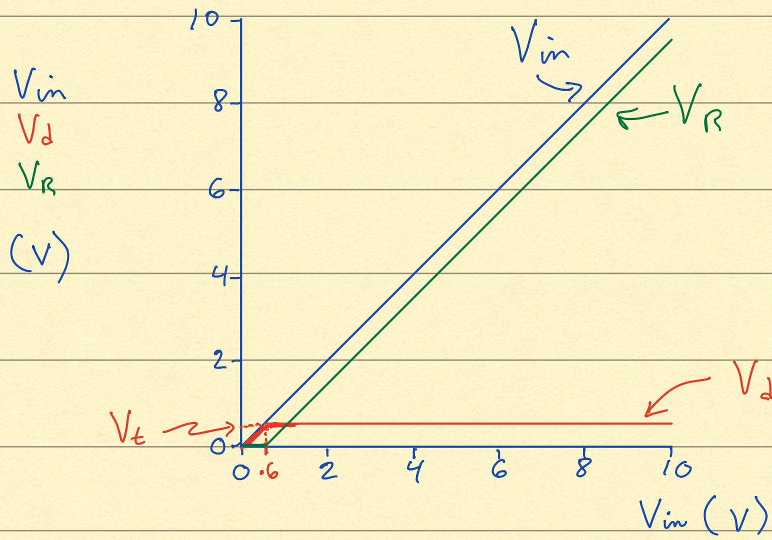
For $V_{in} > V_t$,



(eq't cct)

$V_d = V_t$

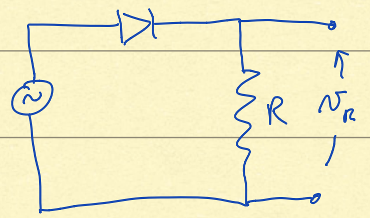
$V_R = V_{in} - V_t$

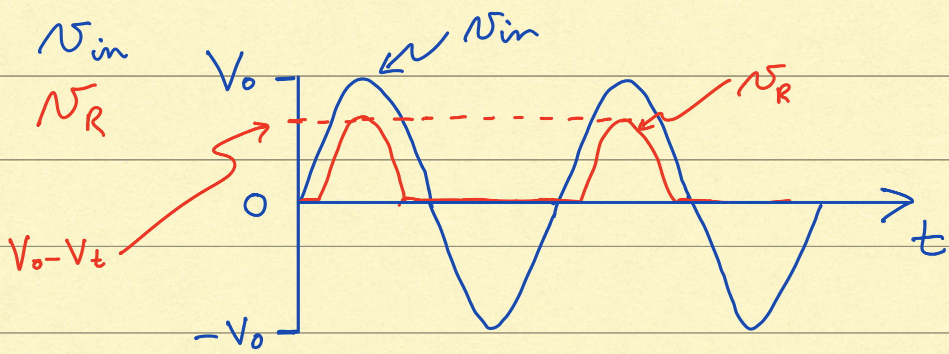


b) Predict the voltage across the resistor, v_R, when the input voltage is supplied by an ac function generator: $v_{in} = V_0 \sin(\omega t)$ where $V_0 > V_t$. *(This is what the waveform will look like on an oscilloscope triggered on positive slope and zero threshold!)* Draw a sketch of both v_{in} and v_R on the same scale, as a function of t.

$v_{in} = V_0 \sin(\omega t)$

$(V_0 > V_t)$





c) Now consider adding a capacitor in parallel with the resistor, as shown in Fig. 4. The result, for an appropriate choice of RC time constant relative to the ac period, is a dc voltage across the capacitor, with some ac "ripple" as shown in Fig. 4. b).

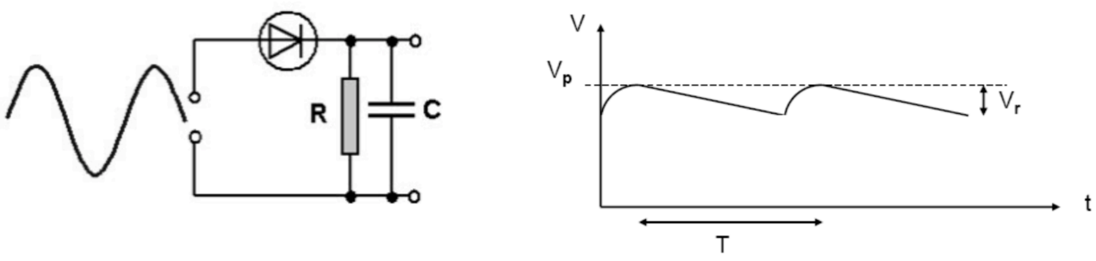
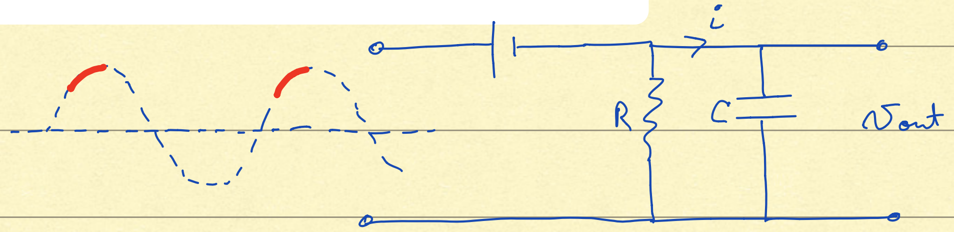


Fig. 4: a) RC filtered rectifier circuit **b) capacitor voltage waveform**

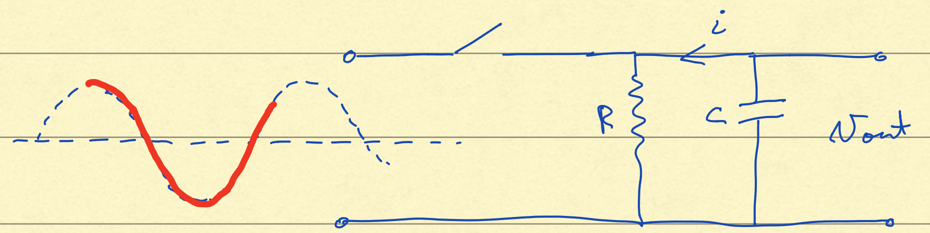
Think carefully about what portion of the ac cycle corresponds to current flowing to charge the capacitor. What happens when the diode turns off? Draw the equivalent circuit in this situation, to show that the capacitor will then discharge through the resistor until the diode turns on again.

For a choice of RC time constant that is large compared to the period of the ac signal, the exponential decay of the capacitor charge can be approximated as linear. Show that in this case, the ratio of the peak-to-peak ripple voltage to the peak (dc) value is **approximately** given by: $\frac{V_r}{V_p} = \frac{1}{RCf}$, where f is the temporal frequency of the ac waveform.

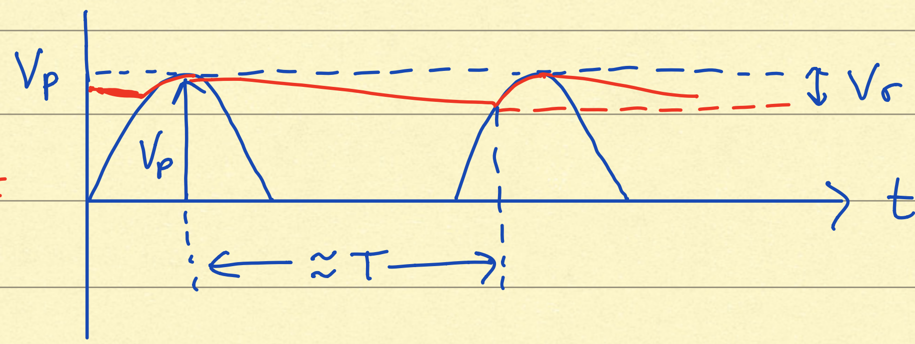
charging cycle



discharge cycle



v_{out}



$v_{out} = v_c = V_p e^{-t/RC} = V_p\left(1 - \frac{t}{RC} + \frac{t^2}{2(RC)^2} + \cdots\right)$ for $t < T$

For $t = T << RC$, $v_c(T) \cong V_p\left(1 - \frac{T}{RC}\right)$

so $V_r \cong V_p - v_c(T) = \frac{V_p T}{RC}$

Then $\frac{V_r}{V_p} \cong \frac{T}{RC} = \frac{1}{fRC}$ using $f = 1/T$