## The University of Sheffield
### Department of Electronic and Electrical Engineering

## EEE103/EEE121/EEE141 Problem Sheet

# Diode, Resistor and Capacitor Circuits.

*NOTE: A pulse described as "long" has a width that is many times the biggest time constant in the circuit of interest. All the pulses used as inputs in this problem sheet have infinitely fast rising and falling edges.*

**Q1** For the circuit of figure 1, sketch the $V_O$ - $V_i$ and $I_D$ - $V_i$ characteristics that you would expect to observe over the range $V_i$ = -10V to $V_i$ = +10V if the diode has a forward voltage drop of 0.7V.

**Q2** For the circuit of figure 2, sketch the waveshape that you would expect to observe if $V_i$ was a triangular waveshape with a peak value of 10V (ie, a positive peak of 10V and a negative peak of -10V) and the diode had a forward voltage drop of 0.7V.

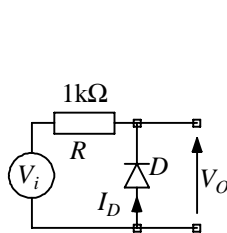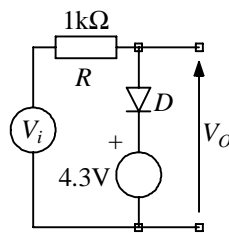What is the largest value of forward current through the diode?
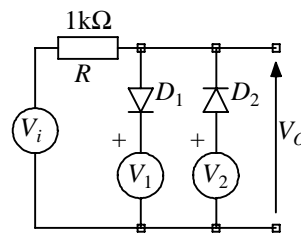


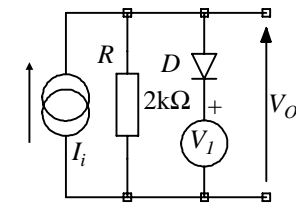**Figure 1**          **Figure 2**          **Figure 3**          **Figure 4**

**Q3** In the circuit of figure 3, $V_i$ is a triangular wave of 10V peak whose frequency is to be measured by a system that requires its input signals to lie within the range 0V to 3.3V if damage to the system is to be avoided. Assuming the diodes have forward bias voltage drops of 0.7V, choose values for $V_1$ and $V_2$ that will clip those parts of the triangular $V_i$ that are higher in voltage than 3.3V and lower in voltage than 0V.

**Q4** In figure 4, $V_1$ = -2V. Sketch $V_O$ as a function of $I_i$ over the range $I_i$ = -3mA to +3mA.

**Q5** Design a soft clipping circuit that will realise the $V_O$-$V_i$ characteristic of figure 5 using diodes that have a turn on voltage of 0.7V. (*Base your design on the circuit of figure 3; keep the 1kΩ resistor, add a series resistor into each of the diode arms and work out suitable values for $V_1$, $V_2$ and the two series resistors.*)
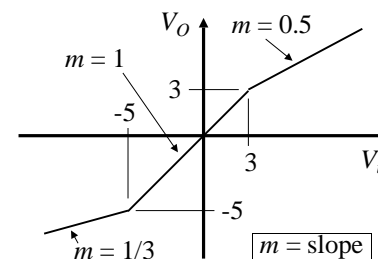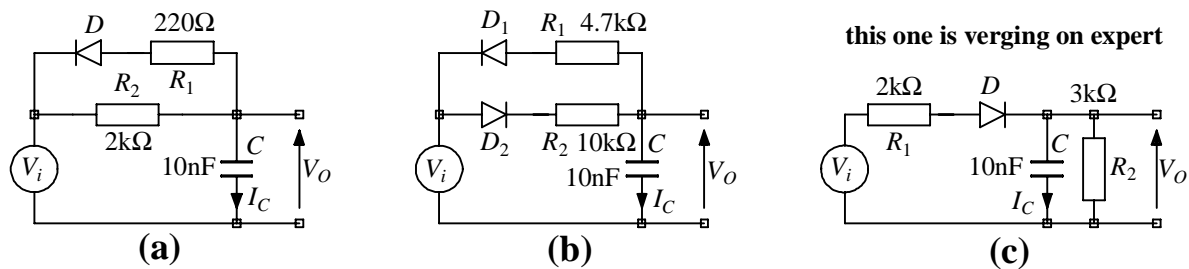


**Figure 5**

**Figure 6**

**Q6** For each of the circuits of figure 6, sketch the response of $V_O$ and $I_C$ to a 0V to 10V input pulse with a duration of 100μs. You should assume that the diodes are ideal (ie, 0V forward voltage drop) and take care to label your sketch with salient features such as time constants and aiming levels. In the case of figure 6b you will need to work out the voltage reached by $V_O$ at the end of the pulse.

In each case write down the exponential form of the rising and falling edge responses and calculate the width of the output pulse, measured in figure 6a and 6c at half its height and measured in 6b at 5V. *(In one of the three circuits the output pulse height is not the same as the input pulse height.)*

### AND FOR EXPERTS

**Q7** The circuits of figure 7 are slightly more subtle in their behaviour than those of figure 6. Each circuit is driven by a 0V to 10V input pulse of 100μs duration and uses diodes that can be assumed to be ideal (ie, 0V forward voltage drop).

For figure 7a, sketch the response of $V_O$ and $I_C$ to the input pulse.

For figures 7b and 7c, sketch the response of $V_O$ to the input pulse.

For figure 7c, calculate the time for which $V_O$ is below 2.5V *after* the falling edge of the input pulse.

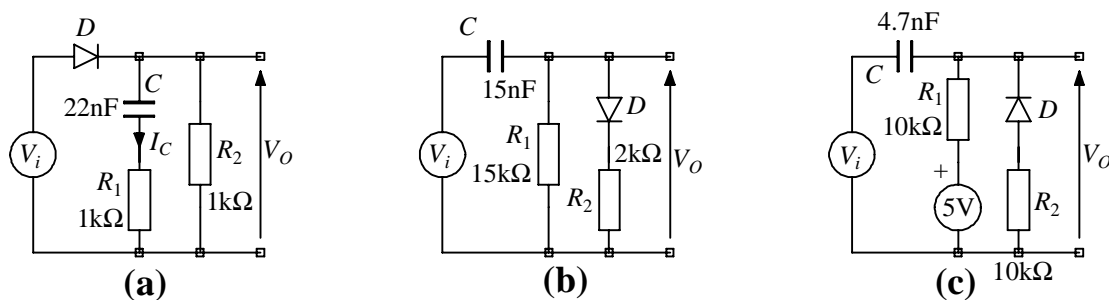As in question 6, be sure to label all the salient features of your sketches.



**Figure 7**