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|                                |                                |                               |                                     |                                |                                  |                                 |                                 |                                  |                                    |                                   |                                   |                                |                                 |                                    |                                   |                                    |                                   |  |
|--------------------------------|--------------------------------|-------------------------------|-------------------------------------|--------------------------------|----------------------------------|---------------------------------|---------------------------------|----------------------------------|------------------------------------|-----------------------------------|-----------------------------------|--------------------------------|---------------------------------|------------------------------------|-----------------------------------|------------------------------------|-----------------------------------|--|
| Periodic Table of the Elements |                                |                               |                                     |                                |                                  |                                 |                                 |                                  |                                    |                                   |                                   |                                |                                 |                                    |                                   | 18                                 |                                   |  |
| 1                              |                                |                               |                                     |                                |                                  |                                 |                                 |                                  |                                    |                                   |                                   |                                |                                 |                                    |                                   |                                    | 2                                 |  |
| 1<br>H<br>Hydrogen<br>1.01     |                                |                               |                                     |                                |                                  |                                 |                                 |                                  |                                    |                                   |                                   |                                |                                 |                                    |                                   |                                    | 2<br>He<br>Helium<br>4.00         |  |
| 2                              |                                |                               |                                     |                                |                                  |                                 |                                 |                                  |                                    |                                   |                                   |                                |                                 |                                    |                                   |                                    |                                   |  |
| 3<br>Li<br>Lithium<br>6.94     | 4<br>Be<br>Beryllium<br>9.01   |                               |                                     |                                |                                  |                                 |                                 |                                  |                                    |                                   |                                   |                                |                                 |                                    |                                   |                                    |                                   |  |
| 11<br>Na<br>Sodium<br>22.99    | 12<br>Mg<br>Magnesium<br>24.31 |                               |                                     |                                |                                  |                                 |                                 |                                  |                                    |                                   |                                   |                                |                                 |                                    |                                   |                                    |                                   |  |
|                                |                                | 13                            | 14                                  | 15                             | 16                               | 17                              |                                 |                                  |                                    |                                   |                                   |                                |                                 |                                    |                                   |                                    | 18                                |  |
|                                |                                | 5<br>B<br>Boron<br>10.81      | 6<br>C<br>Carbon<br>12.01           | 7<br>N<br>Nitrogen<br>14.01    | 8<br>O<br>Oxygen<br>16.00        | 9<br>F<br>Fluorine<br>19.00     | 10<br>Ne<br>Neon<br>20.18       |                                  |                                    |                                   |                                   |                                |                                 |                                    |                                   |                                    |                                   |  |
|                                |                                | 13<br>Al<br>Aluminum<br>26.98 | 14<br>Si<br>Silicon<br>28.09        | 15<br>P<br>Phosphorus<br>30.97 | 16<br>S<br>Sulfur<br>32.07       | 17<br>Cl<br>Chlorine<br>35.45   | 18<br>Ar<br>Argon<br>39.95      |                                  |                                    |                                   |                                   |                                |                                 |                                    |                                   |                                    |                                   |  |
| 19<br>K<br>Potassium<br>39.10  | 20<br>Ca<br>Calcium<br>40.08   | 21<br>Sc<br>Scandium<br>44.96 | 22<br>Ti<br>Titanium<br>47.87       | 23<br>V<br>Vanadium<br>50.94   | 24<br>Cr<br>Chromium<br>51.99    | 25<br>Mn<br>Manganese<br>54.94  | 26<br>Fe<br>Iron<br>55.85       | 27<br>Co<br>Cobalt<br>58.93      | 28<br>Ni<br>Nickel<br>58.69        | 29<br>Cu<br>Copper<br>63.55       | 30<br>Zn<br>Zinc<br>65.38         | 31<br>Ga<br>Gallium<br>69.72   | 32<br>Ge<br>Germanium<br>72.63  | 33<br>As<br>Arsenic<br>74.92       | 34<br>Se<br>Selenium<br>78.97     | 35<br>Br<br>Bromine<br>79.90       | 36<br>Kr<br>Krypton<br>84.80      |  |
| 37<br>Rb<br>Rubidium<br>84.47  | 38<br>Sr<br>Strontium<br>87.62 | 39<br>Y<br>Yttrium<br>88.91   | 40<br>Zr<br>Zirconium<br>91.22      | 41<br>Nb<br>Niobium<br>92.91   | 42<br>Mo<br>Molybdenum<br>95.95  | 43<br>Tc<br>Technetium<br>98.91 | 44<br>Ru<br>Ruthenium<br>101.07 | 45<br>Rh<br>Rhodium<br>102.91    | 46<br>Pd<br>Palladium<br>106.42    | 47<br>Ag<br>Silver<br>107.87      | 48<br>Cd<br>Cadmium<br>112.41     | 49<br>In<br>Indium<br>114.82   | 50<br>Sn<br>Tin<br>118.71       | 51<br>Sb<br>Antimony<br>121.76     | 52<br>Te<br>Tellurium<br>127.6    | 53<br>I<br>Iodine<br>126.90        | 54<br>Xe<br>Xenon<br>131.29       |  |
| 55<br>Cs<br>Cesium<br>132.91   | 56<br>Ba<br>Barium<br>137.33   | 57-71<br>Lanthanides          | 72<br>Hf<br>Hafnium<br>178.49       | 73<br>Ta<br>Tantalum<br>180.95 | 74<br>W<br>Tungsten<br>183.84    | 75<br>Re<br>Rhenium<br>186.21   | 76<br>Os<br>Osmium<br>190.23    | 77<br>Ir<br>Iridium<br>192.22    | 78<br>Pt<br>Platinum<br>195.09     | 79<br>Au<br>Gold<br>196.97        | 80<br>Hg<br>Mercury<br>200.59     | 81<br>Tl<br>Thallium<br>204.38 | 82<br>Pb<br>Lead<br>207.2       | 83<br>Bi<br>Bismuth<br>208.98      | 84<br>Po<br>Polonium<br>[209]     | 85<br>At<br>Astatine<br>[209]      | 86<br>Rn<br>Radon<br>222.02       |  |
| 87<br>Fr<br>Francium<br>223.02 | 88<br>Ra<br>Radium<br>226.03   | 89-103<br>Actinides           | 104<br>Rf<br>Rutherfordium<br>[261] | 105<br>Db<br>Dubnium<br>[262]  | 106<br>Sg<br>Seaborgium<br>[266] | 107<br>Bh<br>Bohrium<br>[264]   | 108<br>Hs<br>Hassium<br>[269]   | 109<br>Mt<br>Meitnerium<br>[268] | 110<br>Ds<br>Darmstadtium<br>[269] | 111<br>Rg<br>Roentgenium<br>[272] | 112<br>Cn<br>Copernicium<br>[277] | 113<br>Nh<br>Nihonium<br>[284] | 114<br>Fl<br>Flerovium<br>[289] | 115<br>Uup<br>Ununpentium<br>[288] | 116<br>Lv<br>Livermorium<br>[293] | 117<br>Uus<br>Ununseptium<br>[294] | 118<br>Uuo<br>Ununoctium<br>[294] |  |

A diagram of a 1D lattice with three sites. The central site is highlighted in light blue. A red arrow points to the central site, and a blue arrow points to the site immediately to its right. A bracket on the right indicates the extent of the lattice.

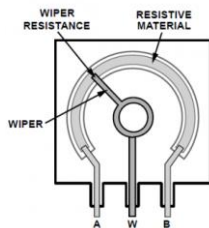
The diagram shows two cross-sectional views of transistors. On the left, an NMOS transistor is shown with a p-substrate. It has a gate stack (G) on top of a channel region (n+). Source (S) and drain (D) regions are also n+, and they are separated from the channel by p+ regions. A back gate (B) is also shown as a p+ region. On the right, a PMOS transistor is shown. It has an n-well on top of a p-substrate. The gate stack (G) is on top of a channel region (p+). Source (S) and drain (D) regions are also p+, and they are separated from the channel by n+ regions. A back gate (B) is also shown as an n+ region.

Draw the P doping mask(s)

# Transistor Lab

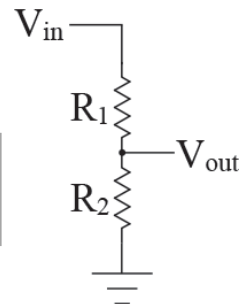
## Passive Electronic Circuit

Build a voltage divider using a potentiometer.



Test the circuit.

$$V_{out} = V_{in} * \frac{R2}{(R1 + R2)}$$



## Transistor Circuit – NPN FET

Use the voltage divider you designed above to measure the *Gate Threshold* voltage for an NPN MOSEFT (IRF510).

Draw test circuit here

Plot  $I_{DS}$  vs.  $V_{GS}$  here



G D S

## Challenge

Build the circuit below. Use an audio signal as input.

What value for R1?

(LED current limit = 25 mA)

Why use the input capacitor?

Replace R4/R3 with your voltage divider.

