Recall how we express numbers in base 2

- $2^2 = 4$'s column
- $2^1 = 2$'s column
- $2^0 = 1$'s column

<table>
<thead>
<tr>
<th>Base Two</th>
<th>Base Ten</th>
</tr>
</thead>
<tbody>
<tr>
<td>000</td>
<td>0</td>
</tr>
<tr>
<td>001</td>
<td>1</td>
</tr>
<tr>
<td>010</td>
<td>2</td>
</tr>
<tr>
<td>011</td>
<td>3</td>
</tr>
<tr>
<td>100</td>
<td>4</td>
</tr>
<tr>
<td>101</td>
<td>5</td>
</tr>
<tr>
<td>110</td>
<td>6</td>
</tr>
<tr>
<td>111</td>
<td>7</td>
</tr>
</tbody>
</table>
Performing logical or arithmetic operations with numbers in binary form

Digital processing is performed by collections of “logic elements” that take one or more inputs and produce an output.

At left is a “Not-And” gate, or a “NAND” gate.

The actual circuit of the NAND gate is shown at right. It requires only that each transistor either be on or off, greatly simplifying requirements on performance.
Understanding how the “nand” gate works

To figure out the output, first determine which transistors are conducting or nonconducting, and then determine whether the output has a clear path to the positive or negative (actually 0) voltage.
Understanding how the “nand” gate works

To figure out the output, first determine which transistors are conducting or nonconducting, and then determine whether the output has a clear path to the positive or negative (actually 0) voltage.
A binary adding circuit

A simple adding circuit can in principle be made entirely out of inverters and not-and or nand gates, both of which are covered in your book.

For each input, the lower position is the one’s column and the upper position is the two’s column.
Question

If we have the following inputs, what will the output be?

For each input, the lower position is the one’s column and the upper position is the two’s column.

A. 010  
B. 001  
C. 100  
D. 011
Electromagnetic Waves and Light
Electromagnetic Waves and Light

Okay .... so what is an electromagnetic wave?
Imagine what happens when you throw a rock into water, or maybe in this case, take something and move it up and down in the water. There is a wave in the water that emanates from the point of disturbance.
If we take a cross section of these waves at some point, it looks like this:

- The speed of water wave has some value I will call $c$.
- The wavelength and frequency are related by a simple equation: $c = \text{frequency} \times \text{wavelength}$
Frequency and wavelength

- Wavelength is the distance over which the wave repeats itself. Thus, the distance between two adjacent peaks, or the distance between two adjacent valleys, etc.
- Frequency is the number of times per second that, for instance, a peak passes a particular point.
Radio waves are generated when charges accelerate back and forth.

A radio transmitter works by pushing charges back and forth in an antenna.
Now that things that are “waving” are electromagnetic fields

- The speed of electromagnetic waves in a vacuum is always the same: $c = 3 \times 10^8 \text{ m/s}$
- The wavelength and frequency are related by a simple equation: $c = \text{frequency} \times \text{wavelength}$
The anatomy of electromagnetic waves

- The wave is perpetuated because of a cycle:
  - The changing magnetic field produces an electric field ...
  - and the changing electric field produces a magnetic field.
- At a snapshot in time, an electromagnetic wave has
  - a sinusoidally varying electric field in one direction,
  - and a corresponding sinusoidally varying magnetic field in the other direction.
- The whole thing propagates along at the speed of light.

Remember that the thing at left is a PLOT electric and magnetic field as a function of z. It is not just a funny shaped thing that moves through space!