Passage III

Relative humidity is a measure of how much water vapor is in the air relative to the total amount of water vapor that the air is capable of holding at a given temperature. Heat index is a combined measure of relative humidity and air temperature. The heat index provides a more accurate indication of the perceived—that is, felt—temperature than is provided by the air temperature alone.

A psychrometer is used to monitor heat index and consists of two traditional bulb thermometers: one “dry” and one “wet.” The dry-bulb thermometer indicates the ambient temperature (current air temperature without regard to humidity or wind). The wet-bulb thermometer is covered with a wet cloth, or wick, and is exposed to moving air for a period. The moisture from the wick evaporates and cools the bulb, lowering its temperature. Once both bulb temperatures are stable, the readings are recorded. A small difference between bulb temperatures—due to a low evaporation rate on the wet-bulb wick—indicates a high relative humidity. A large difference between bulb temperatures—due to a high evaporation rate on the wet-bulb wick—indicates low relative humidity.

To determine the measure of relative humidity, the intersection of the dry-bulb and wet-bulb temperatures is located on a psychrometric graph (Figure 2). Absolute humidity is the amount of water carried in the air, as measured in grams of water per kilogram of air. The ratio of the absolute humidity to the maximum amount of water that the air can hold gives the relative humidity, expressed as a percentage.

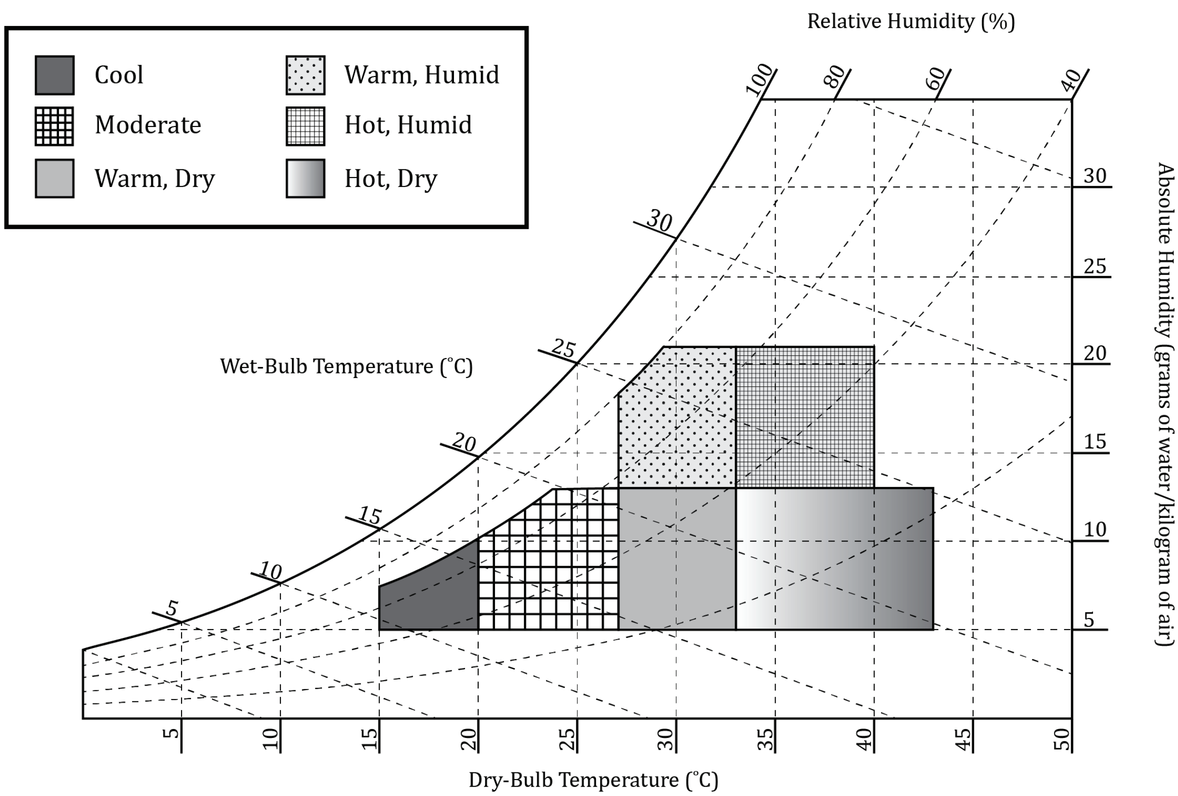

Figure 2

To determine the heat index, the intersection of the dry-bulb temperature and the relative humidity is located on a heat index graph (Figure 3). Certain ranges of heat indices correspond to warning level categories regarding sunstroke and heat exhaustion. There are four main warning levels as indicated in Table 1.

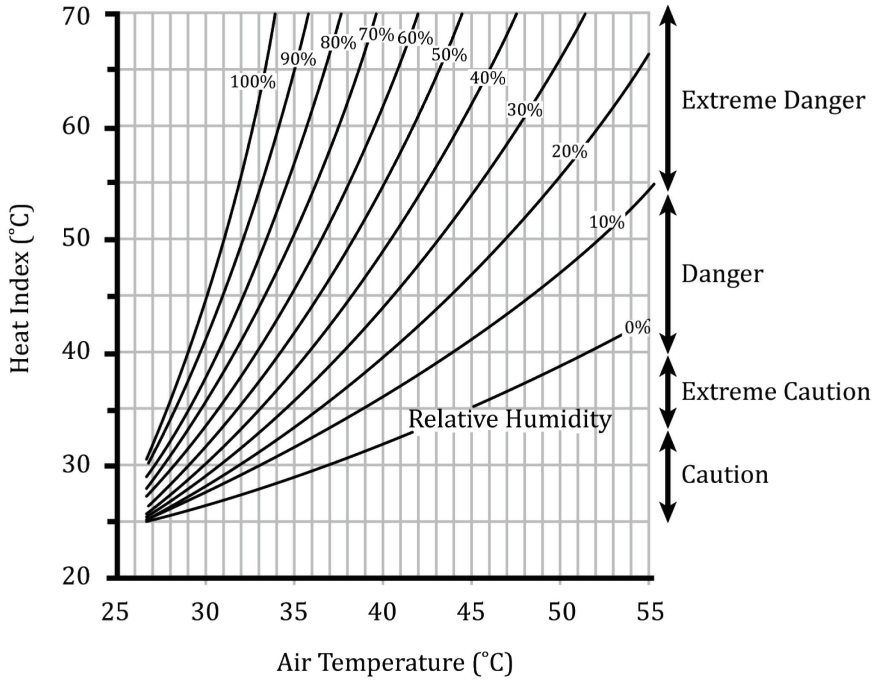

Figure 3

Table 1: Heat Index Warning Categories	
Caution	Fatigue is possible with prolonged exposure and/or physical activity.
Extreme Caution	Sunstroke, heat cramps, and heat exhaustion are possible with prolonged exposure and/or physical activity.
Danger	Sunstroke, heat cramps, and heat exhaustion are likely. Heatstroke is possible with prolonged exposure and/or physical activity.
Extreme Danger	Heatstroke/sunstroke is highly likely with continued exposure.

A group of students used a psychrometer to conduct dry- and wet-bulb measurements at several locations in and around their school. The results are summarized in Table 2.

Table 2: Experimental Measurements

Measurement Location	Dry-Bulb Temperature (°C)	Wet-Bulb Temperature (°C)	Relative Humidity (%)
Classroom	23	13	30
Basement	16	11	50
Shower room	27	24	80
Greenhouse	32	26	60
Outdoors	30	27	80

Passage IV

A charged particle experiences a force when moving through a magnetic field. If a magnet is placed in the vicinity of a current-carrying wire of conducting material, the wire will experience a force due to the interaction between the magnetic field and the charged particles moving through the wire.

To study the interaction between a current-carrying wire and a magnetic field, a group of students conducted a series of experiments using a current balance (Figure 4), in which a current passing through a conducting loop of wire, or current loop, is acted on by the magnetic field produced by a permanent magnet. The current in the loop is produced using a variable power supply connected to the loop. The magnet, with a channel in its center, is placed on a digital electronic scale.

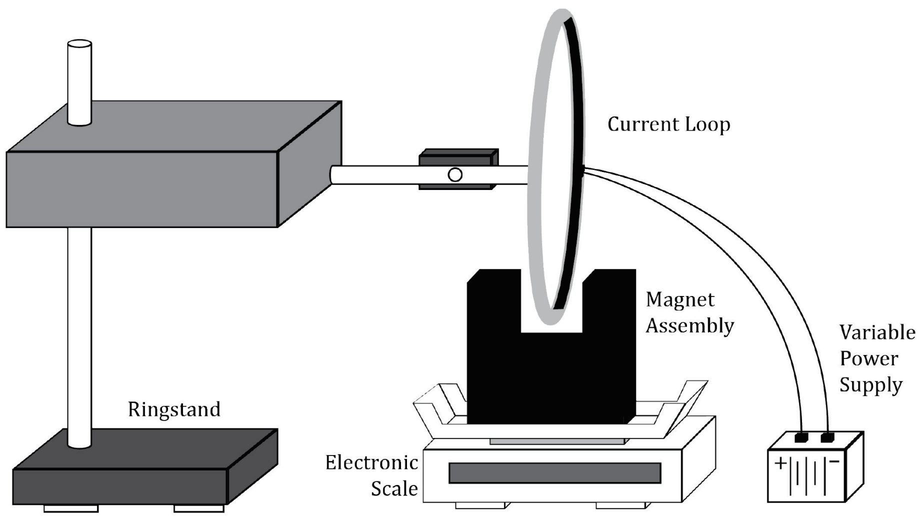

Figure 4

When lowered into the channel of the magnet, the current loop experiences a force due to the magnetic field produced by the magnet, as given by:

$F = ILB$ (Equation 1)

where I is the current in the wire in amperes (A), L is the length of the current loop in meters (m), and B is the magnetic field strength in teslas (1 T = 1 kg/A/s^2). The standard unit of force is the newton (1 N = 1 kg • m/s^2).

Newton's third law of motion, or the law of action-reaction, states that the force on the current loop is equal to the force on the scale. According to Newton's second law of motion, the force on the scale is:

$F = ma$ (Equation 2)

where m is the scale reading in kilograms (kg) and a is the acceleration due to gravity (9.8 m/s^2).

Experiment 1

To demonstrate how currents through the loop are affected by a magnetic force, the students applied different currents to a loop of length 2.4 cm. First, with the magnet in place and no current loop, the scale was zeroed so that scale readings with the current loop in the magnet channel correspond solely to the force acting on the current loop. Then the current loop was placed in the magnet channel without any part of the loop touching the magnet. The power supply was set to 0.5 A and the scale reading was recorded. This was repeated for increased current in steps of 0.5 A up to a maximum of 4.0 A. The students used Newton's second law of motion to calculate the force on the scale and thus the force on the current loop. The results are summarized in Table 3.

Table 3: Experiment 1 Data and Calculations			
Trial	Current, *I* (A)	Scale Reading, *m* (10^{-4} kg)	Force, *F* (10^{-2} N)
1	0.5	3.6	0.35
2	1.0	7.2	0.71
3	1.5	10.7	1.05
4	2.0	14.3	1.41
5	2.5	18.0	1.76
6	3.0	21.6	2.12
7	3.5	25.1	2.46
8	4.0	28.8	2.82

Experiment 2

To determine how the length of the current loop affects the magnetic force acting on it, Experiment 1 was repeated using four different current loop lengths: 1.2 cm, 2.4 cm, 3.6 cm, and 4.8 cm. The scale reading was recorded while 1.5 A of current was applied to each current loop length lowered into the magnet channel. The results are summarized in Table 4.

Table 4: Experiment 2 Data and Calculations			
Trial	Loop Length, *L* (10^{-2} m)	Scale Reading, *m* (10^{-4} kg)	Force, *F* (10^{-2} N)
1	1.2	5.4	0.53
2	2.4	10.7	1.05
3	3.6	15.9	1.56
4	4.8	21.6	2.12

Experiment 3

To determine how the strength of the magnetic field affects the magnetic force acting on the current loop, Experiment 1 was repeated using different numbers of parallel magnets. Each time a magnet was added, the scale was zeroed. For each magnet arrangement, the scale reading was recorded while 1.5 A of current was applied to a 2.4 cm loop lowered into the center magnet channel. The results are summarized in Table 5.

Table 5: Experiment 3 Data and Calculations			
Trial	Number of Magnets	Scale Reading, *m* (10^{-4} kg)	Force, *F* (10^{-2} N)
1	1	10.7	1.05
2	2	21.6	2.12
3	3	32.3	3.17
4	4	42.9	4.20