

**PROBLEM 1.3.1**

**GOAL** : Derive conversion factors from U.S. Customary to SI for (a)-(d)

**GIVEN** : four units, (a)-(d)

**ASSUME** : none necessary

**DRAW** : none necessary

**FORMULATE EQUATIONS and SOLVE** (a) Pressure, lb/ in<sup>2</sup>:

$$\frac{1 \text{ lb}}{1 \text{ in}^2} \left( \frac{4.4482 \text{ N}}{1 \text{ lb}} \right) \left( \frac{12 \text{ in}}{0.3048 \text{ m}} \right)^2 = 6894.72 \text{ N/m}^2$$

**FORMULATE EQUATIONS and SOLVE** (b) Force, kip:

$$1 \text{ kip} \left( \frac{1000 \text{ lb}}{1 \text{ kip}} \right) \left( \frac{4.4482 \text{ N}}{1 \text{ lb}} \right) = 4448.2 \text{ N}$$

**FORMULATE EQUATIONS and SOLVE** (c) Volume, ft<sup>3</sup>:

$$1 \text{ ft}^3 \left( \frac{0.3048 \text{ m}}{1 \text{ ft}} \right)^3 = 0.0283 \text{ m}^3$$

**FORMULATE EQUATIONS and SOLVE** (d) Area, in<sup>2</sup>:

$$1 \text{ in}^2 \left( \frac{0.3048 \text{ m}}{12 \text{ in}} \right)^2 = 0.0006452 \text{ m}^2$$

**RESULTS** :

(a)	1 lb/ in <sup>2</sup>	=	6894.72 N/m <sup>2</sup>
(b)	1 kip	=	4448.2 N
(c)	1 ft <sup>3</sup>	=	0.0283 m <sup>3</sup>
(d)	1 in <sup>2</sup>	=	0.0006452 m <sup>2</sup>

**CHECK** : Check calculations, or perform reverse conversion to ensure accuracy.

**PROBLEM 1.3.2**

**GOAL** : Derive conversion factors from SI to U.S. Customary for (a)-(d)

**GIVEN** : four units, (a)-(d)

**ASSUME** : none necessary

**DRAW** : none necessary

**FORMULATE EQUATIONS and SOLVE** (a) Pressure, N/m<sup>2</sup>:

$$\frac{1 \text{ N}}{1 \text{ m}^2} \left( \frac{0.2248 \text{ lb}}{1 \text{ N}} \right) \left( \frac{1 \text{ m}}{3.2808 \text{ ft}} \right)^2 = 0.0209 \text{ lb/ft}^2$$

**FORMULATE EQUATIONS and SOLVE** (b) Pressure, MPa:

$$1 \text{ MPa} \left( \frac{1 \times 10^6 \text{ Pa}}{1 \text{ MPa}} \right) \left( \frac{0.2248 \text{ lb}}{1 \text{ N}} \right) \left( \frac{1 \text{ m}}{3.2808 \text{ ft}} \right)^2 = 20,885 \text{ lb/ft}^2$$

**FORMULATE EQUATIONS and SOLVE** (c) Volume, m<sup>3</sup>:

$$1 \text{ m}^3 \left( \frac{3.2808 \text{ ft}}{1 \text{ m}} \right)^3 = 35.313 \text{ ft}^3$$

**FORMULATE EQUATIONS and SOLVE** (d) Area, mm<sup>2</sup>:

$$1 \text{ mm}^2 \left( \frac{3.2808 \text{ ft}}{1000 \text{ mm}} \right)^2 = 0.0000108$$

**RESULTS** :

(a)	1 N/m <sup>2</sup>	=	0.0209 lb/ft <sup>2</sup>
(b)	MPa	=	20,885 lb/ft <sup>2</sup>
(c)	1 m <sup>3</sup>	=	35.313 ft <sup>3</sup>
(d)	1 mm <sup>2</sup>	=	0.0000108 ft <sup>2</sup>

**CHECK** : Check calculations, or perform reverse conversion to ensure accuracy.

**PROBLEM 1.3.3**

**GOAL** : Calculate Green's 100-meter dash average speed in m/s, ft/s and mph.

**GIVEN** : time of 9.79 seconds

**ASSUME** : none necessary

**DRAW** : none necessary

**FORMULATE EQUATIONS and SOLVE** :

For m/s:

$$\frac{100 \text{ m}}{9.79 \text{ s}} = 10.21 \text{ m/s}$$

For ft/s:

$$\frac{100 \text{ m}}{9.79 \text{ s}} \left( \frac{3.2808 \text{ ft}}{1 \text{ m}} \right) = 33.512 \text{ ft/s}$$

For mph:

$$\frac{100 \text{ m}}{9.79 \text{ s}} \left( \frac{3.2808 \text{ ft}}{1 \text{ m}} \right) \left( \frac{1 \text{ mile}}{5280 \text{ ft}} \right) \left( \frac{3600 \text{ s}}{1 \text{ hr}} \right) = 22.85 \text{ mph}$$

**RESULTS** : The average speed is:

10.21 m/s
33.51 ft/s
22.85 mph

**CHECK** : Check calculations.

**PROBLEM 1.3.4**

**GOAL** : Calculate the percent difference between the mile and the metric mile

**GIVEN** : a metric mile is 1500 meters

**ASSUME** : none necessary

**DRAW** : none necessary

**FORMULATE EQUATIONS and SOLVE** :

Convert 1 mile to meters:

$$1 \text{ mile} \left( \frac{5280 \text{ ft}}{1 \text{ mile}} \right) \left( \frac{0.3048 \text{ m}}{1 \text{ ft}} \right) = 1609.34 \text{ m}$$

Calculate the percent difference (difference divided by the average):

$$\frac{1609.34 - 1500}{\frac{1}{2}(1500 + 1609.34)} * 100 = 7.03\%$$

**RESULTS** : The percent difference is:

$$\boxed{7.03\%}$$

**CHECK** : Check calculations. Note that percent difference is different from percent error, which would be the difference divided by the “correct” number.

**PROBLEM 1.3.5**

**GOAL** : Calculate Ndereba's average time per mile, and her average speed in m/s. Compared to Laroupe, calculate how much faster Ndereba ran each mile or the race.

**GIVEN** : Marathon is 26.2 miles, Ndereba's time was 2:18.47, Laroupe's time was 2:20.43.

**ASSUME** : none necessary

**DRAW** : none necessary

**FORMULATE EQUATIONS and SOLVE** :

Ndereba's time per mile:

$$\frac{138.78 \text{ min}}{26.2 \text{ mile}} = 5.30 \text{ min/ mile}$$

Ndereba's average speed:

$$\frac{26.2 \text{ mile}}{138.78 \text{ min}} \left( \frac{5280 \text{ ft}}{1 \text{ mile}} \right) \left( \frac{0.3048 \text{ m}}{1 \text{ ft}} \right) \left( \frac{1 \text{ min}}{60 \text{ s}} \right) = 5.064 \text{ m/s}$$

Difference per mile

$$\frac{140.72 \text{ min} - 138.78 \text{ min}}{26.2 \text{ mile}} \left( \frac{60 \text{ s}}{\text{min}} \right) = 4.43 \text{ s/mile}$$

**RESULTS** :

Ndereba's time per mile:	5.30 min
Ndereba's average speed:	5.064 m/s
Ndereba ran each mile faster by:	4.43 s

Note that the difference between the two runners could also be expressed in minutes (0.074 min), or as a difference in average speed (5.064 m/s for Ndereba vs 5.00 m/s for Laroupe, or 0.07 m/s difference).

**CHECK** : Check calculations, and ensure that these values seem realistic.

**PROBLEM 1.3.6**

**GOAL** : Complete the tables

**GIVEN** : two tables for men's and women's world records, 1.3.6a and 1.3.6b

**ASSUME** : none necessary

**DRAW** : none necessary

**FORMULATE EQUATIONS** and **SOLVE** : using conversion factors from table 1.3.

**RESULTS** for Table 1.3.6a:

Event	m	cm	in	ft	mi
High jump	2.45	245	96.5	8.04	1.52E-03
Pole vault	6.14	614	241.7	20.14	3.82E-03
Long jump	8.95	895	352.4	29.37	5.56E-03
Triple jump	18.29	1829	720.1	60.01	1.14E-02
Shot put	23.12	2312	910.2	75.85	1.44E-02
Discus throw	74.08	7408	2916.5	243.04	4.60E-02
Hammer throw	86.74	8674	3414.9	284.58	5.39E-02
Javelin throw	98.48	9848	3877.2	323.10	6.12E-02

**RESULTS** for Table 1.3.6b:

Event	m	cm	in	ft	mi
High jump	2.09	209	82.3	6.86	1.30E-03
Pole vault	4.62	462	181.9	15.16	2.87E-03
Long jump	7.52	752	296.0	24.67	4.67E-03
Triple jump	15.50	1550	610.2	50.85	9.63E-03
Shot put	22.63	2263	890.9	74.25	1.41E-02
Discus throw	76.80	7680	3023.6	251.97	4.77E-02
Hammer throw	76.07	7607	2994.9	249.57	4.73E-02
Javelin throw	67.09	6709	2641.3	220.11	4.17E-02

**CHECK** : Use extra tables values to make sure conversions are correct.

**PROBLEM 1.3.7**

**GOAL** : Convert the record mass to slugs and calculate the weight in newtons and pounds. Estimate how many people it would take to clean and jerk a Porsche 911 if each could match Weller's record.

**GIVEN** : Weller's record mass 262.5 kg. 2005 Porsche 911 standard curb weight of 3075 lb

**ASSUME** : Earth gravity

**DRAW** : none necessary

**FORMULATE EQUATIONS and SOLVE** :

Weller's record in slugs:

$$262.5 \text{ kg} \left( \frac{0.06852 \text{ slug}}{1 \text{ kg}} \right) = 17.99 \text{ slug}$$

Weight in newtons:

$$262.5 \text{ kg} (9.81 \text{ m/s}^2) = 2575.1 \text{ N}$$

Weight in pounds:

$$2575.1 \text{ N} \left( \frac{0.2248 \text{ lb}}{1 \text{ N}} \right) = 578.9 \text{ lb}$$

Given the 911 curb weight, calculate the number of Weller's necessary:

$$3075 \text{ lb} \left( \frac{1 \text{ Weller}}{578.9 \text{ lb}} \right) = 5.3 \text{ Weller}$$

Thus it will take a minimum of 6 (very strong) people to clean and jerk a Porsche 911.

**RESULTS** :

Weller's record in slugs:	17.99 slugs
Weight in Newtons:	2575.1 N
Weight in Pounds:	578.9 lb
Number of world-record holders to clean and jerk a Porsche 911:	6

**CHECK** : Check calculations, and ensure that these values seem realistic.

**PROBLEM 1.3.8**

**GOAL :** For the linear spring specified, (a) Calculate the spring stiffness in SI and U.S. Customary units.  
(b) Calculate the unstretched length in SI and U.S. Customary units.

**GIVEN :** At 180mm, the spring has a tensile force of 170N. At 160mm, the spring has a compressive force of 120N.

**ASSUME :** none necessary

**DRAW :** none necessary

**FORMULATE EQUATIONS and SOLVE :**

Stiffness is given as force over distance

$$\frac{170 \text{ N} - (-120 \text{ N})}{180 \text{ mm} - 160 \text{ mm}} = 14.5 \text{ N/mm} = 14,500 \text{ N/m}$$

Convert to U.S. Customary

$$1.45\text{E}+04 \text{ N/m} \left( \frac{0.2248 \text{ lb}}{1 \text{ N}} \right) \left( \frac{1 \text{ m}}{3.2808 \text{ ft}} \right) = 994 \text{ lb/ft}$$

Unstretched length

$$180 \text{ mm} - 170 \text{ N} \left( \frac{1 \text{ mm}}{14.5 \text{ N}} \right) = 168.276 \text{ mm}$$

Convert to U.S. Customary

$$0.168276 \text{ m} \left( \frac{3.2808 \text{ ft}}{1 \text{ m}} \right) = 0.552 \text{ ft}$$

**RESULTS :**

Stiffness:	1.45E+04 N/m	9.94E+02 lb/ft
Unstretched Length:	1.68E-01m	5.52E-01ft

**CHECK :** Check calculations, and ensure that these values seem realistic.

**PROBLEM 1.4.1**

**GOAL** : Determine the direction of the missing axis (into or out of the page)

**GIVEN** : Four sets of axes

**ASSUME** : Right-hand rule

**DRAW** : No drawings necessary

**FORMULATE EQUATIONS** and **SOLVE** : No equations necessary

**RESULTS** : Using the right-hand rule:

- |     |                   |
|-----|-------------------|
| (a) | z-axis points out |
| (b) | z-axis points in  |
| (c) | x-axis points out |
| (d) | y-axis points out |

**CHECK** : Each frame can be constructed using one's hands, following the convention of Figure 1.3.

**PROBLEM 1.4.2**

**GOAL** : State which coordinate systems are right-handed, include assumptions.

**GIVEN** : four coordinate systems

**ASSUME** : (a) z-axis in the plane of the page, (b) x-axis in the plane of the page, (c) y-axis in the plane of the page, (d) z-axis in the plane of the page

**DRAW** : none necessary

**FORMULATE EQUATIONS** and **SOLVE** : none necessary

**RESULTS** :

(a)	yes
(b)	no
(c)	no
(d)	no

**CHECK** : Use right-hand rule

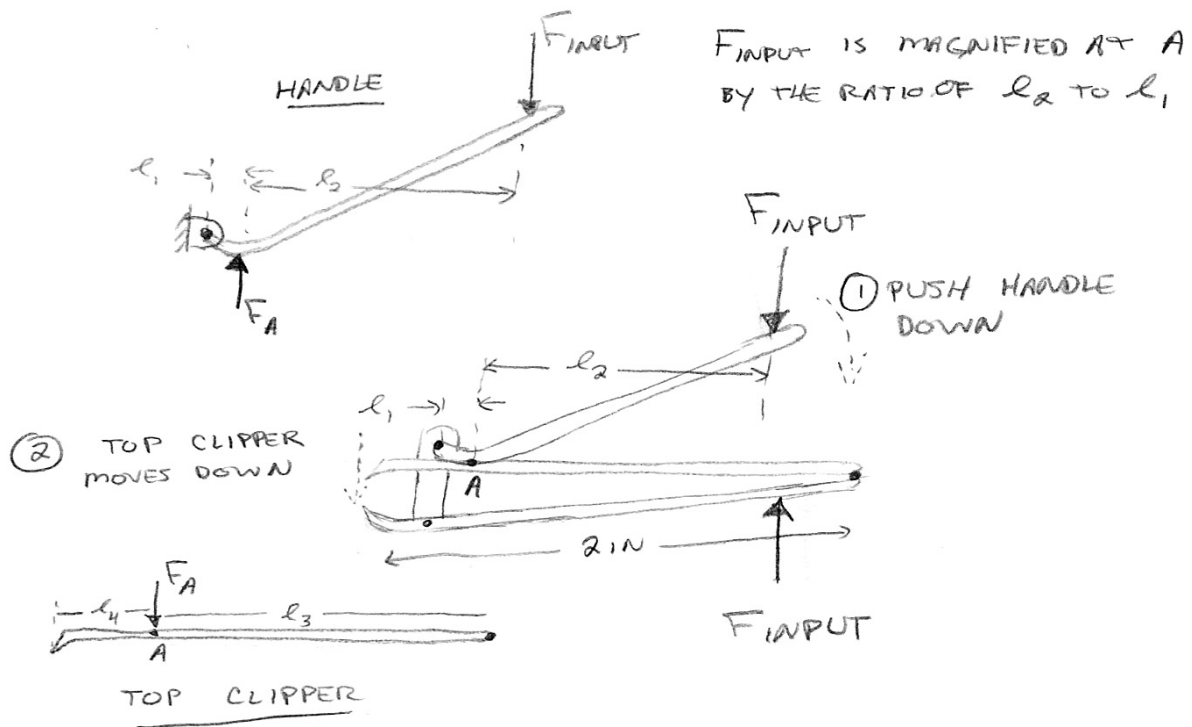
**PROBLEM 1.5.1**

**GOAL** : Sketch three devices that convert human input into some other force or movement and show how you think it works and what forces are involved.

**GIVEN** : No givens.

**ASSUME** : No assumptions necessary

**DRAW** : Here is one device as an example:



**FORMULATE EQUATIONS and SOLVE** : none necessary

**RESULTS** : Particular attention should be paid to guidelines given in Section 1.5, especially the last four items listed in Box 1.3. These include proportion, scale, symbols and planning. Objects should be in good proportion, there should be a sense of scale to the drawing (using something of known size, a textual note, grid, or a few dimensions), appropriate use of symbols (arrows, people, coordinates, etc.), and proper planning to show multiple views, etc.

**CHECK** : Review the items in Box 1.3 to ensure conformity.

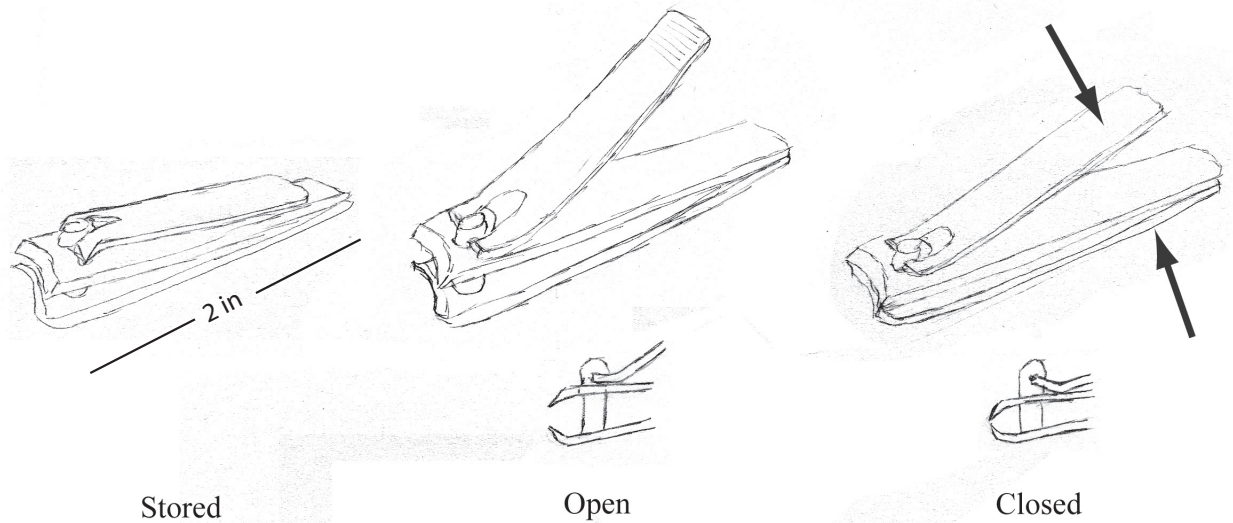
**PROBLEM 1.5.2**

**GOAL** : Create a storyboard of how an artifact works or is operated

**GIVEN** : none

**ASSUME** : none

**DRAW** : Here is an example of a simple storyboard:



**FORMULATE EQUATIONS** and **SOLVE** : none

**RESULTS** : Particular attention should be paid to guidelines given in Section 1.5, especially the last four items listed in Box 1.3. These include proportion, scale, symbols and planning. Objects should be in good proportion, there should be a sense of scale to the drawing (using something of known size, a textual note, grid, or a few dimensions), appropriate use of symbols (arrows, people, coordinates, etc.), and proper planning to show multiple views, etc.

**CHECK** : Review the items in Box 1.3 to ensure conformity.

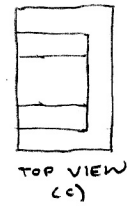
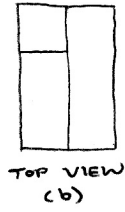
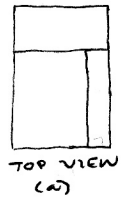
**PROBLEM 1.5.3**

**GOAL** : Sketch the missing top views

**GIVEN** : Three multi-view drawings (a)-(c)

**ASSUME** : No assumptions necessary

**DRAW** and **RESULTS** :



**CHECK** : Reconstruct either the side or front view from the other two to ensure correctness.

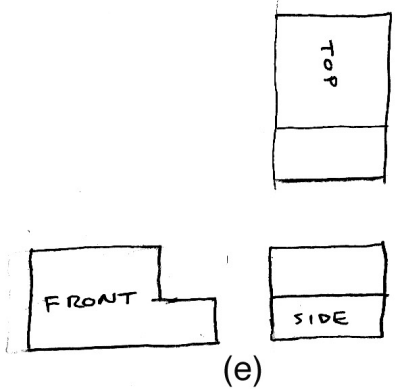
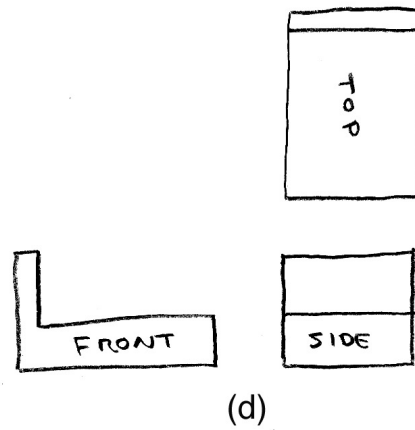
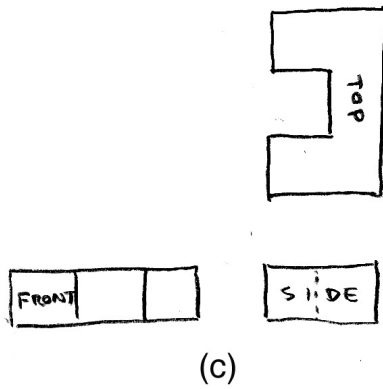
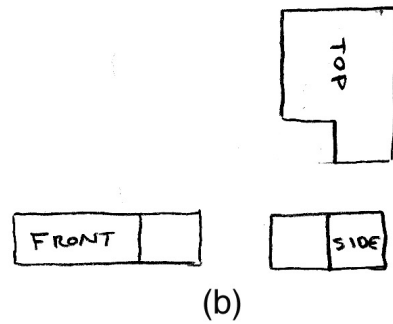
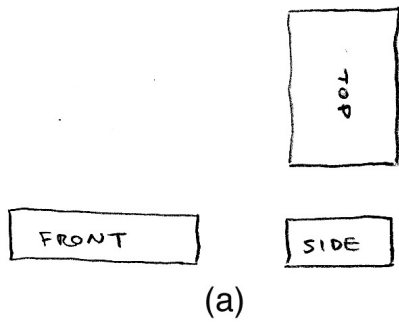
**PROBLEM 1.5.4**

**GOAL :** Sketch the front, side and top views for the five objects in E1.5.4

**GIVEN :** five objects, (a)-(e)

**ASSUME :** No assumptions necessary

**DRAW and RESULTS :**



**CHECK :** reconstruct the three-dimensional images.