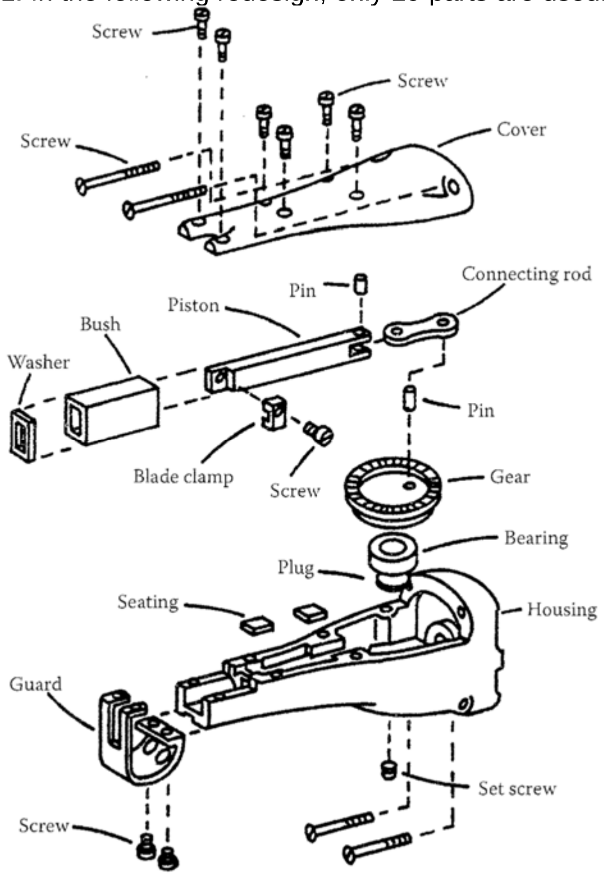
ME3210 Spring 2016 HW1 Solution

1. In the following redesign, only 29 parts are used:



2. Analysis of the parts indicates that:

(a) The strap does not move relative to these parts and so theoretically it can be combined with any of them. (b)The strap does not have to be of a different material-in fact it could be of the same plastic material as the body of the sensor and therefore take the form of two lugs with holes projecting from the body. At this point in the analysis, the designer would probably determine that since the sensor is a purchased stock item, its design could not be changed. However, it is important to ignore these economic considerations at this stage and consider only theoretical possibilities. (3) The strap clearly does not have to be separate from the sensor in order to allow the assembly of the sensor, and therefore none of the three criteria are met and the strap becomes a candidate for elimination. For the strap, a zero is placed in the column for minimum parts.

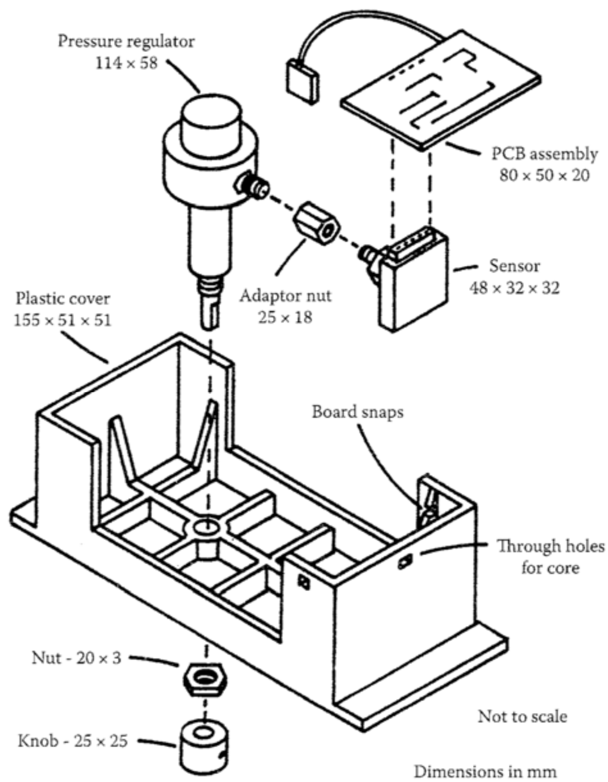
Thus, for the product, the theoretical minimum number of parts is five – pressure regular, metal frame, sensor, PCB assembly, and knob assembly. The Design Efficiency is

$$E_m = \frac{(NM)t_a}{TM} = \frac{5 \times 3}{227.43} = 6.6\%$$

Combining the plastic cover with the metal frame would eliminate the assembly operation for the cover, the three screws, and the reorientation operation. A summary of the design changes and the associated time savings are listed below:

	Design Change	Items	Time Saving (s)
1.	Combine plastic cover with frame, eliminate three screws, and a reorientation	19, 20, 21	52.05
2.	Eliminate strap and two screws (provide snaps in plastic frame to hold sensor if necessary)	6, 7	24.1
3.	Eliminate screws holding PCB assembly (provide snaps in plastic frame)	13	17.1
4.	Eliminate two reorientations	4, 16	9.0
5.	Eliminate tube assembly and two screw fastening operations (screw adaptor nut and sensor direct to the pressure regulator)	10, 11	17.4
6.	Eliminate earth lead (not required with plastic frame)	15	8.7
7.	Eliminate connector (plug sensor into PCB)	14	5.25

The following Figure is a redesign of the controller in which all the proposed design changes are made. The Table that follows is the corresponding revised worksheet. The total assembly time is now 83.98 s and the assembly efficiency is increased to 17.8%.



Item name	Number of items	Handling time per item, s	Insertion time per item, s	Total operation time, s	Figures for min. parts	Description
1. Pressure regulator	1	1.95	1.50	3.45	1	Place in fixture
2. Plastic cover	1	1.95	5.50	7.45	1	Add and hold down
3. Nut	1	1.13	8.00	9.13	0	Add and screw fasten
4. Knob assembly	1	1.95	6.50	8.45	1	Add and screw fasten
5. Screw fastening	1		5.00	5.00		Operation
6. Reorientation	1		9.00	9.00		Reorient
7. Apply tape	1		12.00	12.00		Operation
8. Adaptor nut	1	1.50	10.50	12.00	0	Add and screw fasten
9. Sensor sub.	1	1.95	8.00	9.90	1	Add and screw fasten
10. PCB assembly	1	5.60	2.00	7.60	1	Add and snap fit
Totals	**10**			**83.98**	**5**	

3.
(1) With the Graphite-HM as fiber:
In the longitudinal direction:

$E_c = 3.5 \times 40\% + 390 \times 60\% = 235.4\text{GPa}$;

$\varepsilon_m = 70 / 3.5 \times 10^3 = 0.02$

$\varepsilon_m = 2{,}400 / 390 \times 10^3 = 0.006$

$$@\varepsilon = 0.006,\ \sigma_c = 2{,}400(60\%) + 3.5 \times 10^3 (0.006)(40\%) = 1{,}448.5\text{MPa}$$

$@\ \varepsilon = 0.02,\ \sigma_c = 0.02(3.5 \times 10^3) = 70\text{MPa}$

The composite strength is 1,448.5MPa

(2) With Kevlar 149 as fiber:

$E_c = 3.5 \times 40\% + 186 \times 60\% = 113\text{GPa}$;

$\varepsilon_f = 3{,}400 / 186 \times 10^3 = 0.018$

$$@\varepsilon = 0.018,\ \sigma_c = 3{,}400(60\%) + 3.5 \times 10^3 (0.018)(40\%) = 2{,}065.2\text{MPa}$$

$@\ \varepsilon = 0.02,\ \sigma_c = 0.02(3.5 \times 10^3) = 70\text{MPa}$

The composite strength is 2,065.2MPa

4. $$C = \left[\frac{mC_m}{1-f}\right] + \left[\frac{\sum C_t}{n}\right] + \frac{1}{\dot{n}}\left[\left(\frac{C_c}{Lt_{wo}}\right) + \dot{C}_{oh}\right]$$

$$C = C' \Rightarrow \left[\frac{mC_m}{1-f}\right] + \frac{1}{\dot{n}}\left[\left(\frac{C_c}{Lt_{wo}}\right) + \dot{C}_{oh}\right]$$

$$= \left[\frac{(1.05)mC_m}{1-f}\right] + \frac{1}{\dot{n}'}\left[\left(\frac{C_c}{Lt_{wo}}\right) + \dot{C}_{oh}\right]$$

$$\Rightarrow \left[\frac{(0.05)mC_m}{1-f}\right] \Big/ \left[\left(\frac{C_c}{Lt_{wo}}\right) + \dot{C}_{oh}\right]$$

$$= \left(\frac{1}{\dot{n}} - \frac{1}{\dot{n}'}\right)$$

$$\Rightarrow \left[\frac{(0.055)(2.5)(100)}{0.9}\right] \Big/ \left[\left(\frac{750000}{(0.45)(5 \times 12 \times 30 \times 24)}\right) + (250 + 25 + 120 + 35)\right]$$

$$= \left(\frac{1}{5} - \frac{1}{\dot{n}'}\right)$$

$\Rightarrow \dot{n}' = 5.97$ parts/hr

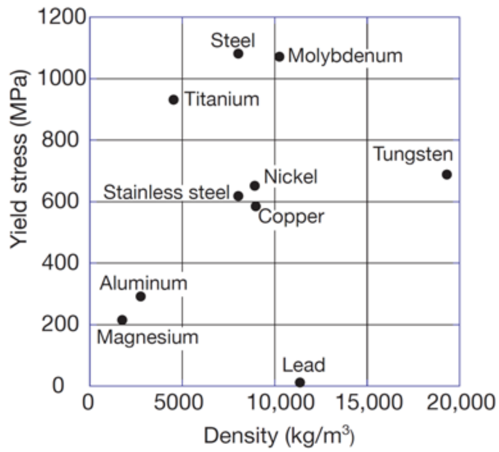
3.1
A unit cell is the smallest group of atoms showing the characteristic lattice structure of a particular metal. A single crystal consists of a number of unit cells; some examples are whiskers, chips for semiconductor devices, and turbine blades.

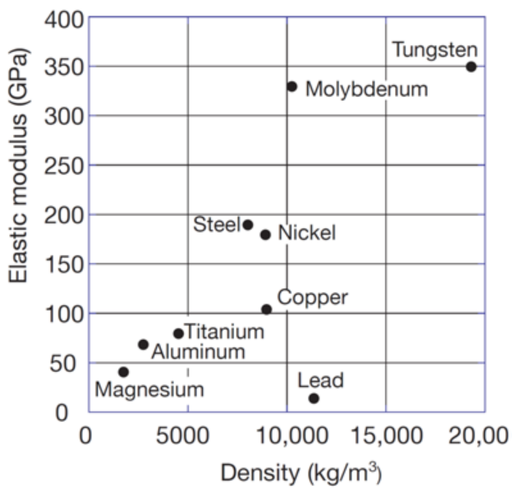
3.27
Some examples are given below.

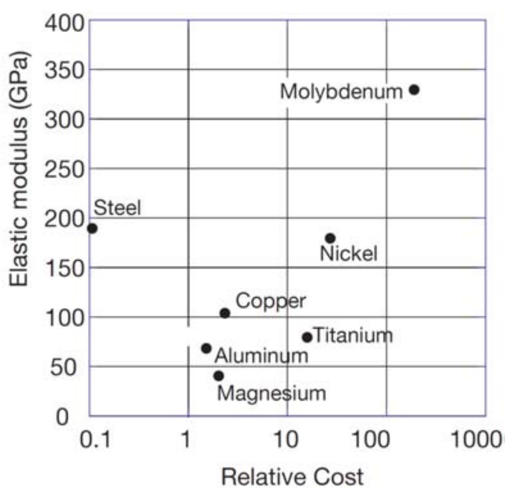
(a) High density: adding weight to a part (such as an anchor for a boat), flywheels, counterweights.
(b) Low melting point: Soldering wire, fuse elements (such as in sprinklers to sense
(c) High thermal conductivity: cookware, car radiators, precision instruments that resist thermal warping. The student is encouraged to site other examples.

3.30
Some of the main concerns associated with aluminum alloys are that, generally, their toughness is lower than steel alloys; thus, unless the automobile is properly designed and tested, its crashworthiness could suffer. A perceived advantage is that weight savings with aluminum result in higher fuel efficiencies, but steel requires much less energy to produce from ore, so these savings are not as high as initially believed.

3.42
The plots are shown below, based on the data given in Tables 2.1 on p. 32, 3.3 on p. 106, and 16.4 on p. 971. Average values have been used to obtain these plots.


1200
1000
800
600
400
200
0
Yield stress (MPa)
Steel
Molybdenum
Titanium
Tungsten
Nickel
Stainless steel
Copper
Aluminum
Magnesium
Lead
0
5000
10,000
15,000
20,000
Density (kg/m^3)


400
350
300
250
200
150
100
50
0
Elastic modulus (GPa)
Tungsten
Molybdenum
Steel
Nickel
Copper
Titanium
Aluminum
Magnesium
Lead
0
5000
10,000
15,000
20,00
Density (kg/m^3)


400
350
300
250
200
150
100
50
0
Elastic modulus (GPa)
Molybdenum
Steel
Nickel
Copper
Titanium
Aluminum
Magnesium
0.1
1
10
100
1000
Relative Cost