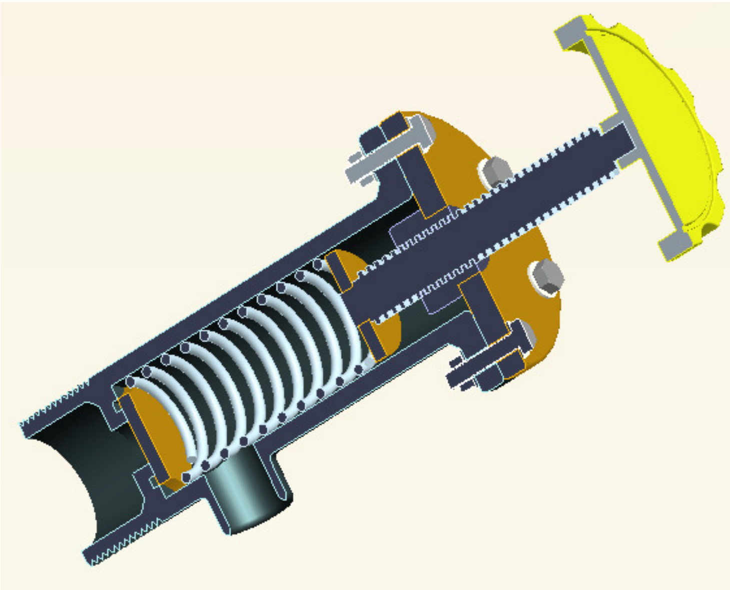
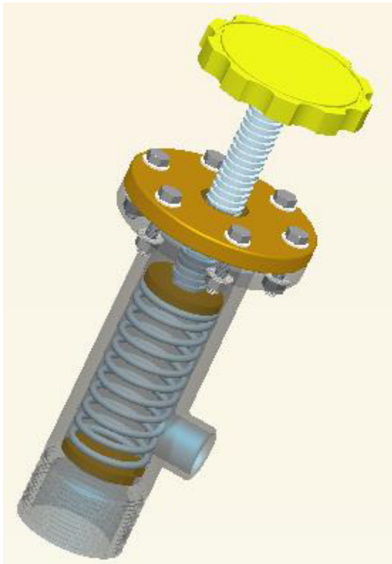
	The Hashemite University Faculty of Engineering *Mechanical Engineering Department*	***Machine Design II*** *Spring 2016/2017* *Instructor: Dr. Ala Hijazi*

Design Project
(*20 points*)

<u>Design of a Pressure Relief Valve</u>





The mechanically controlled valve shown is to be used for relieving excess pressure in fluid lines. It enables the limiting value of pressure to be adjusted by means of power screw and spring. The pressure coming from the fluid line acts against the lower surface of the valve plate which is sealed using a confined gasket inserted in the groove shown. The spring applies a counterforce against the plate in order to keep it in position and prevent the fluid from escaping. When the fluid pressure in the line exceeds the preset limiting value it overpowers the spring and thus moves the valve plate allowing the fluid to escape through the side vent.

Design a pressure relief valve that works according to the concept described above.
Your design should meet the following constraints:

- Adjustable pressure setting from zero to maximum value.
- The valve is to be threaded into a standard size fitting.
- Minimum of six bolts for fixing the top-cover.
- Valve Body:
    - American standard pipe (Sch-40) for the body and smaller size pipe for the side vent (*length of the side vent valve should be at least 1/6 of the length of the pipe used for the body*)
    - Standard thickness plates (*<u>preferred sizes Table A-17</u>*) for all plates and flanges.
    - Determine the thickness of the top cover to resist bending then use the same plate thickness for all other plates and flanges.
    - Flanges to be welded to the pipe.
- Spring:
    - One millimeter radial clearance between the spring and the pipe inner surface.
    - Number of active turns can be up to 50.

- Power Screw:
  - Standard size with preferred pitch, Acme thread, single or multiple threads.
  - Self locking with the number of revolutions to reach maximum pressure setting (starting from zero pressure) between 10 and 20.
  - Bronze nut with height such that at least six threads are engaged.
- Static factors of safety:

  $n_s \geq 1.2$ for the spring (at solid length).

  $n_s \geq 2$ for the power screw.

  $n_s \geq 5$ for all other components.
- Available materials:
  - Hard-drawn and music wires.
  - AISI 1030 HR steel for pipes and plates.
  - Heat treated AISI 1040 steel for the power screw (*you need to specify the heat treatment*).
  - AWS E70xx electrodes.
  - ISO classes 4.8 and 9.8.
- Use the following additional figure of merit:
  - Bolts: ***fom = (MRC).D.N*** *(use the ISO class number as the MRC)*

- Your design should meet all the requirements while maintaining a minimal cost.

The table below lists the specific design requirements for each group:

Group #	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12***	***13***	***14***	***15***	***16***
Pipe Nominal Diameter *in*	2	2	2	2	2 ½	2 ½	2 ½	2 ½	3	3	3	3	3	3	3	3
Seal Inner Diameter *mm*	25	25	25	25	30	30	30	30	35	35	35	35	40	40	40	40
Maximum Pressure *bar*	40	50	60	70	40	50	60	70	40	50	60	70	40	50	60	70

Each group needs to turn in a technical report showing the design procedure and results. SI units must be used in the calculations and the report should include:

- ***Design procedure, equations, table of iterations (if applicable) for each component.***
- ***Final detailed design assessment for all components.***
- ***Detailed engineering drawings for all components.***
- ***Detailed cost calculation per valve.***

You can use the flowing information for calculating the cost per valve.

- Your cost calculations should be based on the production of 30 valves.
- Pipes come in *6 m* long sections while the plates come in square or rectangular shapes with *0.5 m* length increments up to a size of *1 m × 2 m*.
- The cost of steel (plates & pipes) is *0.6 JD/kg* while the scrap is sold at *0.3 JD/kg*.
- The cost for other components and manufacturing operations is as follows:
  - Power screw: ***cost = (D/10) + (D×L×6×10^{-4}) JD/screw*** *(dimensions in mm).*
  - *Springs*: ***cost = D×d×N ×6×10^{-4} JD/spring*** *(dimensions in mm).*
  - Fasteners: ***cost = D×L×2×10^{-3} JD/fastener*** *(dimensions in mm).*
  - Weldments: ***cost =t×L×2×10^{-4} JD*** *(dimensions in mm).*
  - Drilling: ***cost = 0.1 JD/hole***
  - Threading: ***cost = 0.1 JD/cm (thread length)***
  - Cutting;
    - Straight cuts of pipes: ***cost = 0.2 JD/cut***
    - Other cuts (plates & curved cuts): ***cost = 1 JD/m***