Design Portfolio (Preliminary)

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Metal Finder

Document Revision History

Ver #	Date	Description of Changes (Section # and Summary Points)	Author
1.0	Dec. 13/16	Initial version reflecting preliminary (V1) design of the model (DBM_MetalFinder_master.ipt)	D.B. McCowan

CONTENTS

Resources

Reference Document / Filename	Description / Key Concepts	Author	For Vn
Rubric_Information_Processing.doc	Information Processing is an element of the Thinking Achievement Category	D.B. McCowan	1
Written_Report_Rubric.doc	Written reports are an element of the Communication Achievement Category (Technical Communication is key)	D.B. McCowan	1
13 Concepts of Technology: (Thinking / Connections)	thinkproblemsolving.org TDJ3M1 Quiz	D.B. McCowan	1
Design_Process_Stages_Details.doc	The Design Process – A Problem-Solving Strategy	D.B. McCowan	1
Pickup folders	Technical communication and design portfolio management	D.B. McCowan	1

Student Assignment: 100 Marks

Use the 3D parametric modelling functionality of Inventor Pro to solve the problem stated below.

1 The Situation – as Told to Me By Someone Else

"SATEC now has a SAWSTOP table saw. If the blade hits a nail – it is a $250 mistake. The brake and the blade must be replaced. And we can't use the SAWSTOP for probably a couple of weeks. So, we must have a convenient way to find nails and screws in salvaged lumber – and why would SATEC want to use salvaged lumber anyway?"

2 Design Brief – My Goal – My Concise Interpretation of the Situation

To design a device(s) – or a system – to find nails, screws and other metal parts in a piece of wood which could potentially cause damage to a table saw or any other wood working tools.

3 Requirements – What My Product Must Look Like… and Perform Like…

#	**Predominant Fundamental Concept of Tech**	**Requirement** (Potentially More Research May Be Required on Each Topic Below)
1	Function / Control	Must indicate the location of the nail within a few square inches
2	Sustainability	Must be clearly marked or labelled "Shop Helper Tool: Nail Finder". Must be stored and used for training people so that it does not get thrown out.
3	Ergonomics	Must be light for portability. The user must be fairly comfortable when using the product.
4	Materials	Should largely be made of wood.
5	Structure	Must be strong enough to survive typical usage in a woodshop.
6	Fabrication	Must be easy to make in our shop
7	Aesthetics	The device does not need to be pretty, but should at least exhibit "pride of craft". The product must look as though the builder was proud of his or her work.
8	Safety	The device must not have sharp edges that could cut people.

4 Planning: Apply What I Already Know; Information Processing; Critical Thinking; Creative Thinking

The day before this assignment was given out, the teacher told us that there is a helpful new quiz on http://thinkproblemsolving.org: ***Nov. 24/16 -- Some Curriculum Connections and Problem-Solving***. It seems that the word "Helpful" is a key word meant to help us. The Situation description states: "*If the blade hits a nail… have a convenient way to find nails…*" so the word "Nail" is a key word for sure.

In the “helpful new quiz” I searched on the word “nail”. There was one hit in question “***B2.2 Apply mathematical and scientific concepts and skills as required in the course of design.***” This is a matching type of question – six of the eleven given statements include the word “lever”. Now I will quote portions of these statements along with my answers:

Statement in Matching Question Quoting question “*B2.2 Apply mathematical and scientific concepts and skills as required in the course of design.*”	**My Answer (True or False)**
The equation: e / r = Dr / De is a valid statement of the law of the lever.	True
The fulcrum of a lever is the pivot point of a balance.	True
A lever can lift a heavy load by using a small effort.	True
To lift a heavy load with a small effort using a lever, you must move your effort through a very small distance.	False
The law of the lever says this: “The effort, e, (say in Newtons) times the distance, De, from the point of application of the effort to the fulcrum (say in metres) is equivalent to the resistance or load, r, (in Newtons) times the distance Dr, from the point of application of the load (resistance) to the fulcrum (metres).”	True
A lever is a balance	True

So I believe the word ***lever*** is also a keyword for me.

Here are my answers to the remaining statements in this matching question.

Statement in Matching Question Quoting question “*B2.2 Apply mathematical and scientific concepts and skills as required in the course of design.*”	**My Answer (True or False)**
In its most general sense, an amplifier is a mechanism or device which magnifies a signal.	True
The main purpose of the SawStop table saw is to easily detect nails in old salvaged lumber.	False
An amplifier can detect a very weak signal and increase the magnitude of that signal so that humans can more easily detect it.	True
Ferrous – iron-bearing – objects (such as most steels) are not attracted to magnets.	False
An algebraic statement of equality (ie an equation with an equal = sign) is a balance.	True

Here is my ***interpretation*** of this matching quiz question: ***This matching quiz question is all about solving the metal-finding problem that we were given.***

My analysis of this question’s statements is this:

- Broken nails can be “hidden” in a piece of salvaged wood – and are thus hard for humans to see or find
- I can find a piece of iron including nails and most screws using a magnet, but the signal coming from a buried piece of metal may be very weak, unless I am creative
- I can create a device that amplifies the weak signal so that I can “see” the nail
- My amplifier device will be a lever where e *x* De = r *x* Dr
    - The lever arm material will be relatively light – ie low density wood such as dry pine
    - De is basically the distance from the centre of mass of the heavy magnet to the lever’s fulcrum
    - Dr is the distance from the centre of mass of the other end of my lever to the fulcrum
    - Dr is significantly greater than De
    - A heavy magnet on the “short end” of my lever will move only a small distance when it is hovered over a steel nail or screw – the signal is relatively weak

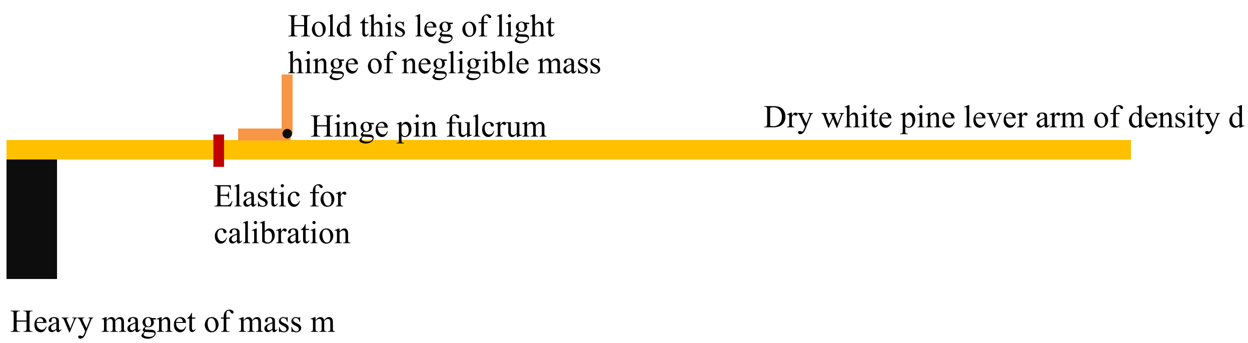
  - Because of my lever design, the "long end" of my lever will move a large distance that I can easily "see", so I will therefore be able to "see" the nail using my device

5 Specifications: A Concise View of "How" I Will Solve the Problem

I will solve the problem and meet the Requirements that I had stated above as follows:

- A hand-held magnet-equipped lever will be used to detect a piece of metal
- The lever arm material will be a piece of long, thin, narrow dry white pine
- The fulcrum will be a very small brass hinge
  - screwed on one face to the pine lever arm
  - hand-held on the other face
- Small but heavy magnets will be ganged-up at the extreme end of the short end of the lever arm
- An elastic will be used as a final calibration piece – I can easily move it closer to or farther from the fulcrum to give the lever perfect balance when a piece of metal is not being detected. This calibration elastic will be required because the pine wood will absorb water in the summer (and get heavier) and give off water in the winter months (and thus get lighter).

6 Sketch



7 Other 3D CAD Strategy Considerations and Simplifications for Version 1 of the Design

- I will place the centre of the hinge pin at the origin of the XY plane
- I will draw my sketch on the XY plane and extrude the profiles symmetrically in both the + and – Z directions
- I will simplify the hinge
- Assumptions:
  - Mass of the hinge and its screws is negligible
  - Density of the magnets is much greater than the density of the white pine
  - Moisture content of the white pine is approx 8%
  - Mass of the calibration elastic is negligible -- but of course the elastic is necessary for final balancing of the system because of my previous assumptions and their resultant uncertaintanties

7.1 System Constraint Parameters (aka “User” Parameters)

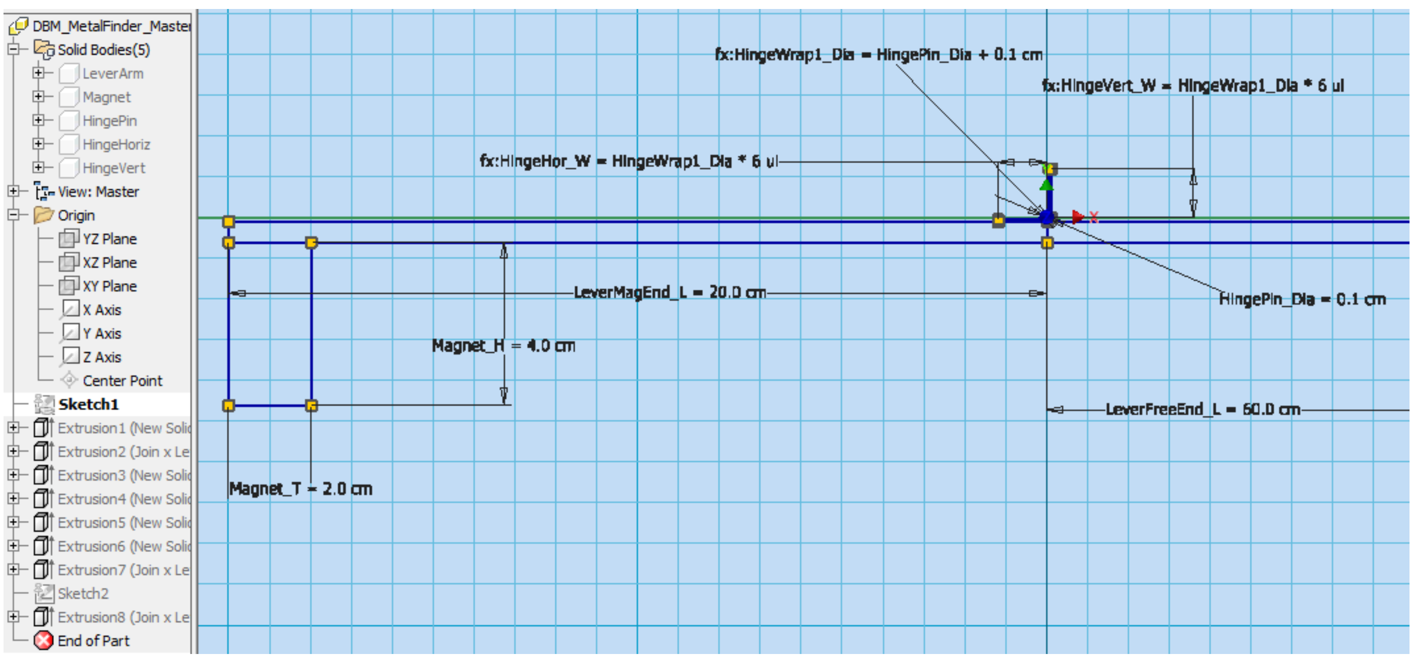
I could set user parameters for the:

- mass of one magnet in grams
- density of white pine at 8% moisture content (grams / cubic centimeter)

I could thus design multiple variations of my tool, each variation having a different number of magnets – the more magnets in a particular variation, the more sensitive my tool will be (ie it will detect smaller bits of iron).

8 Version 1 Solution

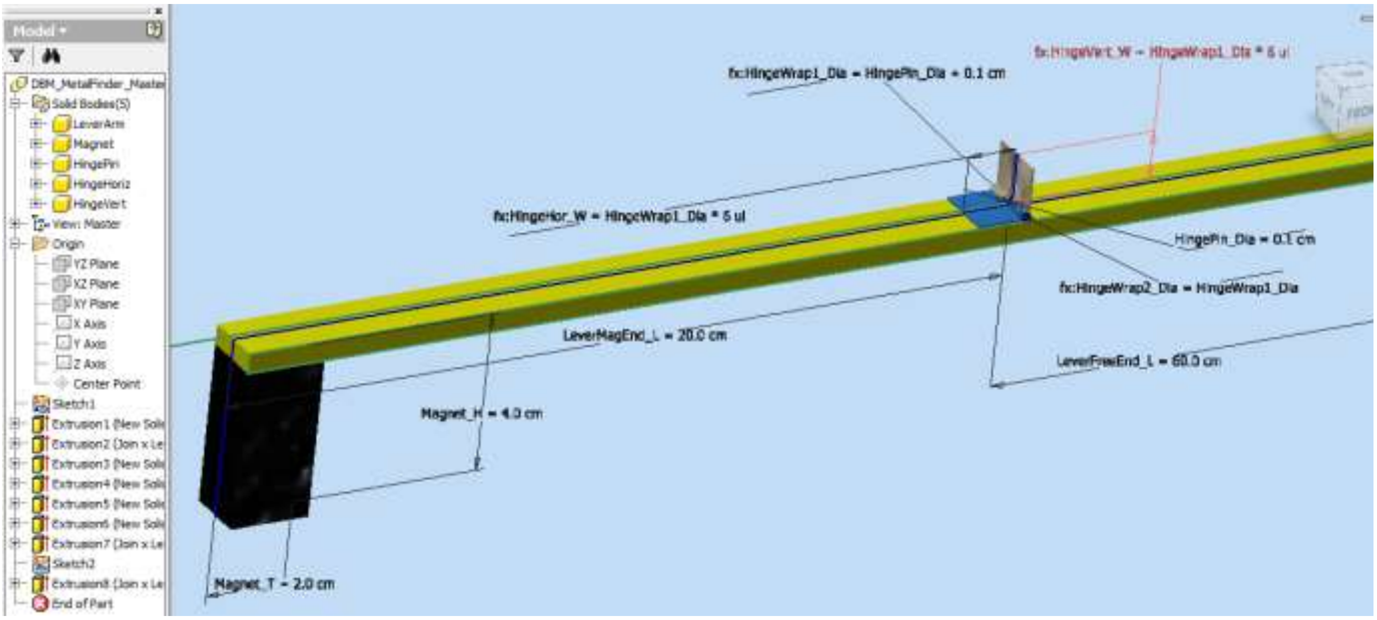
8.1 Screen-Shots of Model Architecture, Parameters etc.

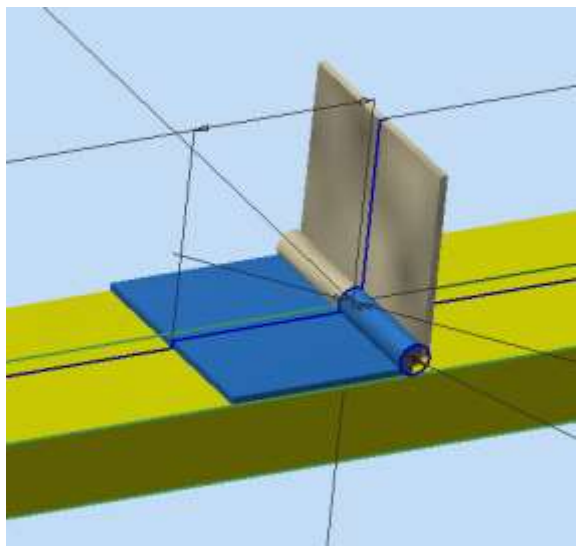


Sketch1 on XY Plane (locking centre of hinge pin to the XYZ coordinate system origin)
Fully constrained with no degrees of freedom.

Sketch 2 is simply another sketch of the hinge wrap, this time to be extruded into the screen, opposite to the direction of the extrusion of HingeWrap1_Dia=HingePin_Dia + 0.1 cm:

HingeWrap2_Dia=HingeWrap1_Dia


Model
Solid Bodies(5)
LeverArm
Magnet
HingePin
HingeHoriz
HingeVert
View: Master
Origin
YZ Plane
XZ Plane
XY Plane
X Axis
Y Axis
Z Axis
Center Point
Sketch1
Sketch2
End of Part
fx:HingeWrap1_Dia = HingePin_Dia + 0.1 cm
fx:HingeVert_W = HingeWrap1_Dia * 6 ul
fx:HingeHor_W = HingeWrap1_Dia * 6 ul
HingePin_Dia = 0.1 cm
fx:HingeWrap2_Dia = HingeWrap1_Dia
LeverMagEnd_L = 20.0 cm
LeverFreeEnd_L = 60.0 cm
Magnet_H = 4.0 cm
Magnet_T = 2.0 cm



Parameter Name	Unit/Ty	Equation	Nominal Value
Model Parameters			
HingePin_Dia	cm	0.1 cm	0.100000
HingeWrap1_Dia	cm	HingePin_Dia + 0.1 cm	0.200000
HingeHor_W	cm	HingeWrap1_Dia * 6 ul	1.200000
HingeVert_W	cm	HingeWrap1_Dia * 6 ul	1.200000
LeverFreeEnd_L	cm	60.0 cm	60.000000
LeverFreeEnd_T	cm	0.5 cm	0.500000
LeverMagEnd_L	cm	20.0 cm	20.000000
Magnet_H	cm	4.0 cm	4.000000
Magnet_T	cm	2.0 cm	2.000000
LeverFreeEnd_W	cm	1.5 cm	1.500000
d10	deg	0.0 deg	0.000000
LeverMagEnd_W	cm	LeverFreeEnd_W	1.500000
d12	deg	0.0 deg	0.000000
Magnet_W	cm	LeverFreeEnd_W	1.500000
d14	deg	0.0 deg	0.000000
HingePin_L	cm	LeverFreeEnd_W	1.500000
d16	deg	0.0 deg	0.000000
HingeHor_L	cm	LeverFreeEnd_W	1.500000
d18	deg	0.0 deg	0.000000
HingeVert_L	cm	LeverFreeEnd_W	1.500000
d20	deg	0.0 deg	0.000000
HingeWrap1_L	cm	LeverFreeEnd_W / 2 ul	0.750000
d22	deg	0.0 deg	0.000000
HingeWrap2_Dia	cm	HingeWrap1_Dia	0.200000
HingeWrap2_L	cm	LeverFreeEnd_W / 2 ul	0.750000
d25	deg	0.0 deg	0.000000
User Parameters			

- DBM_MetalFinder_Master.ipt
  - Solid Bodies(5)
    - LeverArm
      - LeverArmFreeEnd_Ext1 (New Solid x 1.5 cm)
      - LeverMagnEnd_Ext2 (Join x LeverFreeEnd_W)
        - Sketch1
    - Magnet
      - Magnet_Ext3 (New Solid x LeverFreeEnd_W)
    - HingePin
      - HingePin_Ext4 (New Solid x LeverFreeEnd_W)
        - Sketch1
    - HingeHoriz
      - HingeHoriz_Ext5 (New Solid x LeverFreeEnd_W)
      - Extrusion7 (Join x LeverFreeEnd_W / 2 ul)
    - HingeVert
      - HingeVert_Ext6 (New Solid x LeverFreeEnd_W)
      - Extrusion8 (Join x LeverFreeEnd_W / 2 ul)
  - View: Master
  - Origin
    - YZ Plane
    - XZ Plane
    - XY Plane
    - X Axis
    - Y Axis
    - Z Axis
    - Center Point
  - Sketch1
  - LeverArmFreeEnd_Ext1 (New Solid x 1.5 cm)
  - LeverMagnEnd_Ext2 (Join x LeverFreeEnd_W)
  - Magnet_Ext3 (New Solid x LeverFreeEnd_W)
  - HingePin_Ext4 (New Solid x LeverFreeEnd_W)
  - HingeHoriz_Ext5 (New Solid x LeverFreeEnd_W)
  - HingeVert_Ext6 (New Solid x LeverFreeEnd_W)
  - Extrusion7 (Join x LeverFreeEnd_W / 2 ul)
  - Sketch2
  - Extrusion8 (Join x LeverFreeEnd_W / 2 ul)
  - End of Part

Name	Date modified	Type	Size
OldVersions	17/12/2016 2:46 PM	File folder	
DBM_Inv2014_MetalFinder.ipj	17/12/2016 2:46 PM	Autodesk Inventor...	8 KB
DBM_MetalFinder_Master.iam	17/12/2016 10:59 ...	Autodesk Inventor...	447 KB
DBM_MetalFinder_Master.ipt	17/12/2016 10:39 ...	Autodesk Inventor...	136 KB
DBMcHingeHoriz.ipt	17/12/2016 10:59 ...	Autodesk Inventor...	71 KB
DBMcHingePin.ipt	17/12/2016 10:59 ...	Autodesk Inventor...	60 KB
DBMcHingeVert.ipt	17/12/2016 10:59 ...	Autodesk Inventor...	71 KB
DBMcLeverArm.ipt	17/12/2016 10:59 ...	Autodesk Inventor...	64 KB
DBMcMagnet.ipt	17/12/2016 10:59 ...	Autodesk Inventor...	64 KB
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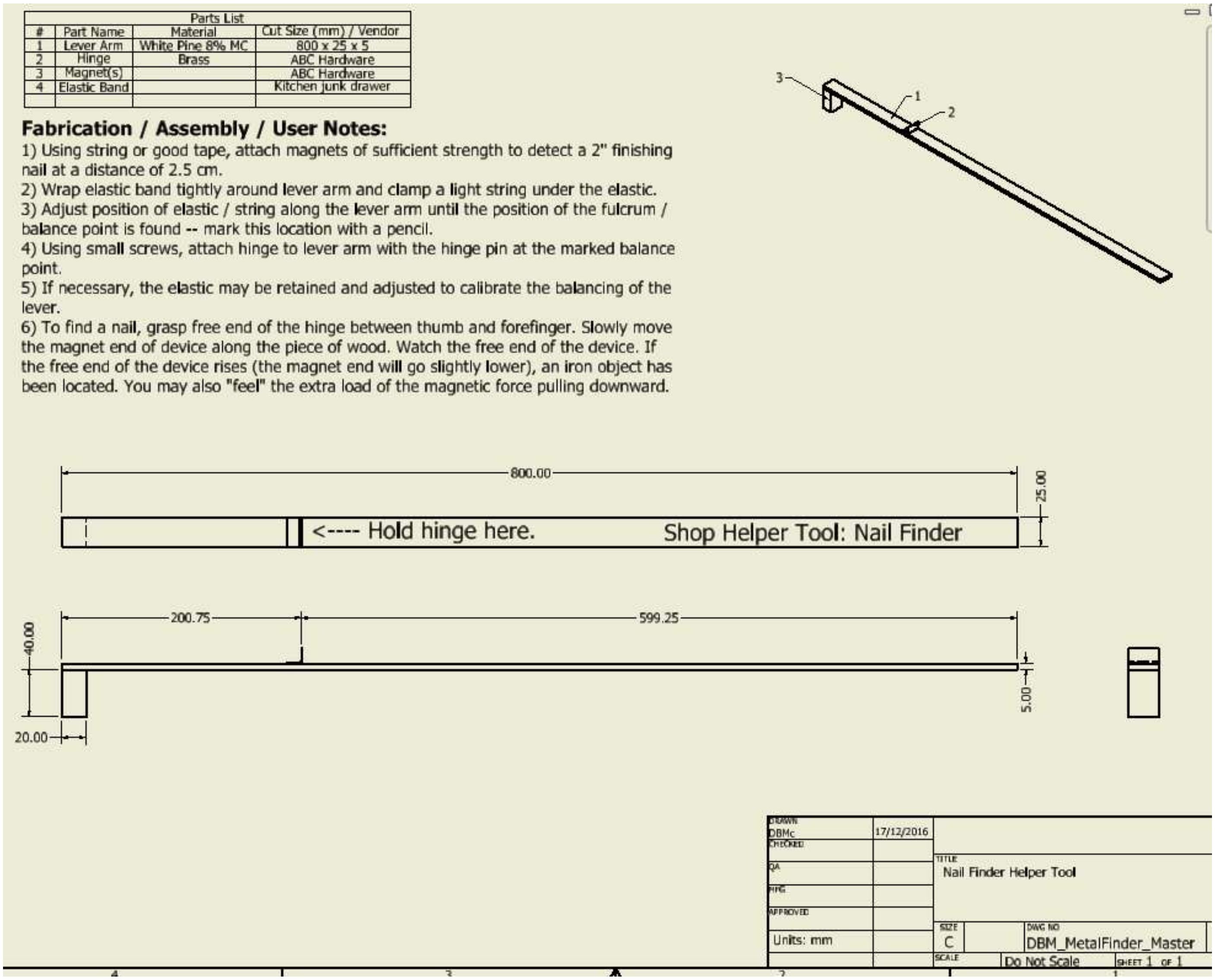
"Make Components" and the contents of the project folder

8.2 Shop Drawing



Parts List			
#	Part Name	Material	Cut Size (mm) / Vendor
1	Lever Arm	White Pine 8% MC	800 x 25 x 5
2	Hinge	Brass	ABC Hardware
3	Magnet(s)		ABC Hardware
4	Elastic Band		Kitchen junk drawer

Fabrication / Assembly / User Notes:

1) Using string or good tape, attach magnets of sufficient strength to detect a 2" finishing nail at a distance of 2.5 cm.
2) Wrap elastic band tightly around lever arm and clamp a light string under the elastic.
3) Adjust position of elastic / string along the lever arm until the position of the fulcrum / balance point is found -- mark this location with a pencil.
4) Using small screws, attach hinge to lever arm with the hinge pin at the marked balance point.
5) If necessary, the elastic may be retained and adjusted to calibrate the balancing of the lever.
6) To find a nail, grasp free end of the hinge between thumb and forefinger. Slowly move the magnet end of device along the piece of wood. Watch the free end of the device. If the free end of the device rises (the magnet end will go slightly lower), an iron object has been located. You may also "feel" the extra load of the magnetic force pulling downward.

9 Self-Assessment

If I had had more time I would have:

1) Researched the density of white pine at 8% moisture content
2) Researched the density of the magnet material
3) Used an iterative process to:
    a) Calculate the centre of gravity of the free end of the lever arm
    b) Calculate the centre of gravity of the magnet end of the lever arm
    c) Calculate the balance point using the law of the lever (see section 4 above)
4) And as I noted in section 7.1 above – add user parameters so that I can generate multiple device variants that have unique metal detection sensitivities.

10 Self and Peer Assessment of This Version of the Report

Assessor's Name and Additional Notes in Red Font: by John Doe