EML2322L Decision Matrix Example

MOBILE PLATFORM	Weighting Factor	Parameter	Design 1			Design 2			Design 3			Design 4			Design 5		
Objective			Mag.	Score	Value	Mag.	Score	Value	Mag.	Score	Value	Mag.	Score	Value	Mag.	Score	Value
Speed	0.20	feet / sec	1.7	4.9	1.0	3.1	8.9	1.8	2.6	7.4	1.5	3.5	10.0	2.0	1.7	4.9	1.0
Controllability	0.30	experience	fair	4	1.2	good	8	2.4	great	10	3.0	poor	2	0.6	great	10	3.0
Manufacturing Time	0.20	hours	8.4	7.1	1.4	8.0	7.5	1.5	10.0	6.0	1.2	6.0	10.0	2.0	6.0	10.0	2.0
Modularity	0.20	fasteners	2	10	2.0	3	7	1.3	4	5	1.0	2	10	2.0	2	10	2.0
Material Cost	0.10	$	28.00	2.7	0.3	8.50	8.8	0.9	19.00	3.9	0.4	7.50	10.0	1.0	7.50	10.0	1.0
Overall value					5.9			7.9			7.1			7.6			9.0

BUCKET MANIPULATOR	Weighting Factor	Parameter	Design 1			Design 2			Design 3			Design 4		
Objective			Mag.	Score	Value	Mag.	Score	Value	Mag.	Score	Value	Mag.	Score	Value
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
Overall value					…			…			…			…

ETCETERA …	Weighting Factor	Parameter	Design 1			Design 2			Design 3			Design 4		
Objective			Mag.	Score	Value	Mag.	Score	Value	Mag.	Score	Value	Mag.	Score	Value
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
Overall value					…			…			…			…

Qualitative Score Assignments:

great	10
good	8
okay	6
fair	4
poor	2

Mobile Platform

Objective Definitions & Weighting Factor Justifications:

Speed is the maximum (loaded) linear velocity of the robot on flat ground. Speed is weighted at 20% because course completion time is a strong function of speed and, after successfully performing the given task, it is the primary criteria by which robot designs are evaluated. The design with the highest loaded linear velocity scores 10 out of 10 possible points. [Note: speed can also be defined relative to a target velocity, set through mobile platform testing.]

Controllability is an assessment of the ability of the driver to control the mobile platform when driving through the tunnel, through the course, and during bucket manipulator alignment. This qualitative assessment is based upon experience gained driving example mobile platforms as shown in *Appendix A*, and was weighted at 30% because the driver must be able to controllably maneuver the robot to retrieve and dispense the balls. Since the successful retrieval and dispensing of the balls is a binary measure of the success of the design, controllability is weighted the most heavily. The most controllable design scores 10 out of 10 possible points. [Note: controllability can also be quantified in several ways.]

Manufacturing Time is an educated estimation of the time (in hours) required to fabricate, modify and assemble all parts for the mobile platform. Manufacturing times are estimated using the provided *Time Estimations for Manufacturing Lab Parts* document detailed in *Appendix A*. Manufacturing time is weighted at 20% because it is imperative to ensure the design can be fabricated and assembled within the given time and capability constraints. The design with the fewest required hours scores 10 out of 10 possible points.

Modularity is an assessment of the mobile platform's ability to be quickly disassembled and reassembled each week in lab. Modularity is quantified using the number of fasteners that must be loosened or removed during disassembly. Modularity is weighted at 20% because all project components must fit in a 17" x 12" x 15" storage box at the end of each lab session, or a penalty will be assessed. The design with the fewest number of fasteners scores 10 out of 10 possible points. [Note: when reporting the number of fasteners that must be loosened or removed, be sure to include a description and reference to a sketch clearly showing the location of these fasteners.]

Material Cost is the cost of the materials that must be purchased to produce the mobile platform. Material cost is weighted at 10% because of the abundance of necessary materials already allowed to each team, along with a budget of $50. Furthermore, there is no added benefit for cheaper designs once the cost is below $50. The design with the lowest material cost scores 10 out of 10 possible points.

Note that speed, manufacturing time and modularity objectives are considered equally important and thus receive equal weighting factors. The relative importance of these objectives was chosen based on a team evaluation of the project description and discussion with course TAs. …

Score Assignments:

Unless otherwise noted, each score assignment that follows is assigned using linear scoring. The "best" concept, as defined in the *Objective Definitions,* is assigned a score of 10 out of 10 possible points; a design with a magnitude equal to either double or half that of the "best" design is assigned 5 out of 10 possible points, with this trend continuing linearly in both directions.

Speed

Design 1 uses the 44 rpm Entstort right angle gear motors and 12" diameter drive wheels, which result in a loaded vehicle speed of 1.7 ft/sec (as seen in *Appendix B: Wheel Speed Calculations*). Since Design 1 travels at 49% of the fastest design's speed (3.5 ft/sec), Design 1 receives a score of 4.9 out of 10 using a linear score assignment. [A more useful approach could be to identify a desired top speed via testing example platforms in office hours, and assign scores in relation to how close each concept's top speed is to that desired parameter.]

Design 2 uses …

Design 3 uses …

Design 4 uses …

Design 5 uses the wheel and motor combination from Design 1, and a new sketch is shown in *Figure 5A* [reference to conceptual sketch from first design report]; the 44 rpm Entstort right angle gear motors coupled with 12" diameter drive wheels result in a loaded linear velocity of 1.7 ft/sec. Design 5 therefore travels at 49% of the fastest design's speed (3.5 ft/sec) and receives a score of 4.9 out of 10 using a linear score assignment.

Controllability

Design 1 uses two 12" drive wheels, two 4" caster wheels as shown in *Figure 4B* [reference to conceptual sketch from first design report], and has a loaded vehicle speed of 1.7 ft/sec. From mobile platform testing, detailed in *Appendix A*, 1.7 ft/sec is easily controllable; however, the four-wheel design may result in situations where one of the drive wheels is out of contact with the floor. Since Design 1 utilizes differential steering, both drive wheels must maintain traction with the floor for robot control. Therefore, Design 1 was assigned a magnitude of fair and, thus, a score assignment of 4.

Design 2 uses …

Design 3 uses …

Design 4 uses …

Design 5 uses the 80/20-frame construction from Design 1, along with two 12" diameter drive wheels and a single 4" caster wheel at the rear of the robot. A new sketch of this design is shown in *Figure 5A* [reference to conceptual sketch from first design report]. Design 5 uses differential steering and the drive wheels must therefore maintain contact with the ground to function properly. Using only three wheels ensures all remain in contact with the ground at all times. Due to this increase in controllability, as it is defined in *Appendix A,* Design 5 was assigned a magnitude of great and, thus, a score assignment of 10.

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.
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Bucket Manipulator

Objective Definitions & Weighting Factor Justifications:

…

Score Assignments:

…

Ball Hopper / Sorter

Objective Definitions & Weighting Factor Justifications:

…

Score Assignments:

…

Appendix A: Decision Matrix Calculations/Justifications

MOBILE PLATFORM MATERIAL COST ESTIMATES

MATERIAL	Unit of Cost [-]	Quantity [-]	Unit Cost [$]	Total Cost [$]
DESIGN 1				
1" 80/20 Aluminum Extrusion	ft	2.0	$3.00	$6.00
3/16"X3" Aluminum Bar Stock	ft	0.8	$4.50	$3.60
2" Aluminum Round Bar Stock	ft	0.3	$20.00	$6.00
20 GA Steel Sheetmetal	ft^2	2.5	$2.35	$5.88
Flange-Mount Ball Transfer McMaster-Carr #5674K51	each	1	$6.53	$6.53
			TOTAL:	**$28.01**
DESIGN 2				
…	…	…	…	…
			TOTAL:	…
DESIGN 3				
…	…	…	…	…
			TOTAL:	…
DESIGN 4				
…	…	…	…	…
			TOTAL:	…
DESIGN 5				
…	…	…	…	…
			TOTAL:	…

NOTE: Cost calculated using provided *Material Price List* and volume ratio calculations shown in *Appendix A*

Material Price List

Description	Price/ft
80/20 1"x1" AL square extrusion	$3.00
1"x0.125" AL square tubing	$1.00
0.125"x1" AL rectangular bar stock	$1.00
0.125"x2" AL rectangular bar stock	$2.00
0.5"x2" AL rectangular bar stock	$8.00
1"x2" AL rectangular bar stock	$16.00
1"x1"x0.125" AL angle	$3.00
1.5"x1.5"x0.125" AL angle	$4.50
2"x2"x0.125" AL angle	$6.00
1" AL round bar stock	$5.00
2" AL round bar stock	$20.00
1" PVC (plastic) pipe	$1.00
2" PVC (plastic) pipe	$2.00
3" PVC (plastic) pipe	$3.00
4" PVC (plastic) pipe	$4.00

Prices on additional materials and sizes not shown available online at

http://mscdirect.com
http://mcmaster.com
http://www.onlinemetals.com/

Computing Cost for Material not on Price List

As you work on your projects and talk with the TAs about material selection, you might find material in the lab that you want to purchase for use on your project, but it's not listed on the material price sheet. Use the equivalent price per volume for the same type of material (aluminum or steel flat bar, round bar, angle, sheet, etc)

If, for example, you desire to make motor mounting brackets out of 3/16" x 4" aluminum flat bar, how would you compute the price?

A quick glance at the price list on the previous page does not show this size material.

We need to use the equivalent price per volume for the same type of material, so let's choose 1/8" x 2" aluminum bar stock, which the price sheet lists as costing $2.00 per foot. To calculate the equivalent price per volume, simply use the ratio of cross sectional areas (since we're still comparing cost per 1 foot length):

$2.00/ft × (3/16" x 4") / (1/8" x 2") = $2.00/ft × (3) = **$6.00/ft**

Therefore, the 3/16" x 4" aluminum flat bar would cost $6.00/ft.

If your design requires two pieces of 3/16" x 4" aluminum flat bar that are 4.5" long each, the total cost would simply be:

$6.00/ft × (1 ft/12 in) × 9" = **<u>$4.50 (ans)</u>**

Sheetmetal Price List

Description	Price/ft^2
0.035" (20 GA) steel sheet	$2.35
0.048" (18 GA) steel sheet	$3.20
0.060" (16 GA) steel sheet	$4.00
0.035" (20 GA) alum sheet	$3.20
0.048" (18 GA) alum sheet	$4.00
0.060" (16 GA) alum sheet	$5.00

Prices on additional sheet-metal or aluminum sizes not shown available locally at

Lowes	**376-9900**
Zells/Ace Hardware	**378-4650**
Boone Welding	**372-9533**
Roger's Welding	**372-7734**

Or online at

http://mscdirect.com
http://mcmaster.com
http://www.onlinemetals.com/

Computing Cost for Sheetmetal

When purchasing sheetmetal for your project, **you must buy the smallest rectangular piece from which you can make your part.** For example, if you need to make a part out of 16 gage steel sheetmetal that measures 6" x 12" and has 3" chamfers on the corners, you must pay for the entire 6" x 12" piece of material (no one will be able to use the "drops" from the corners of the part).

To calculate the price for this part, simply look up the cost for 16 gage steel sheetmetal from the previous page ($4.00/ft^2) and scale accordingly:

$4.00/ft^2 × (6 in x 12 in) / (144 in^2/ft^2) = **$2.00 (ans)**

Therefore, our part would cost $2.00 if made from 16 gage steel sheetmetal.

Ball Transfers

For information about ball transfers, see page 1287.

Flange-Mount Ball Transfers

Transfers can be used ball up, ball down, or at an angle, unless noted. Temp. range for nylon and acetal balls and housings is 32° to 195°F.

Ball Dia.	Ball Material	Housing Material	Cap., lbs.	(A)	Flange Size Lg.	Flange Size Wd.	Bolt Holes Ctr.-to-Ctr.	Bolt Holes Dia.		
General Purpose										
1 .... 1″	Steel	Black Nylon	110	1³⁄₈″	2²⁹⁄₃₂″	2¹⁄₁₆″	2³⁄₈″	⁹⁄₃₂″	**5674K51**●	$6.53
1 .... 1″	Stainless Steel	Gray Nylon	110	1³⁄₈″	2²⁹⁄₃₂″	2¹⁄₁₆″	2³⁄₈″	⁹⁄₃₂″	**5674K53**●	16.08
2 .... 1″	Acetal	White Nylon	20	1⁵⁄₁₆″	2¹⁄₂″	1³⁄₄″	1³⁄₄″	⁷⁄₃₂″	**5674K77**●	14.57
3 .... 1″	Steel	Zinc-Plated Steel	75	1³⁄₁₆″	2³⁄₄″	2″	2³⁄₁₆″	⁷⁄₃₂″	**5674K1**♦	3.07
3 .... 1″	Steel	Zinc Plated Steel	150	1³⁄₁₆″	2³⁄₄″	2″	2³⁄₁₆″	⁷⁄₃₂″	**5674K14**♦	5.50
3 .... 1″	Nylon	Zinc-Plated Steel	75	1³⁄₁₆″	2³⁄₄″	2″	2³⁄₁₆″	⁷⁄₃₂″	**5674K47**♦	13.41
3 .... 1″	Nylon	Stainless Steel	35	1³⁄₁₆″	2³⁄₄″	2″	2³⁄₁₆″	⁷⁄₃₂″	**5674K28**	28.58
3 .... 1″	Stainless Steel	Zinc-Plated Steel	75	1³⁄₁₆″	2³⁄₄″	2″	2³⁄₁₆″	⁷⁄₃₂″	**5674K17**♦	16.50
3 .... 1″	Stainless Steel	Stainless Steel	125	1³⁄₁₆″	2³⁄₄″	2″	2³⁄₁₆″	⁷⁄₃₂″	**5674K13**♦	31.31
4 .... ¹¹⁄₁₆″	Steel	Black-Oxide Steel	90	1″	2⁷⁄₁₆″	1¹¹⁄₁₆″	2″	⁵⁄₃₂″	**5674K57**	7.12
4 .... 1″	Steel	Black-Oxide Steel	135	1⁹⁄₃₂″	2⁷⁄₁₆″	1¹¹⁄₁₆″	2″	⁵⁄₃₂″	**5674K58**	8.20
5 .... 1″	Steel	Black-Oxide Steel	135	1¹⁄₂″	2⁷⁄₁₆″ Dia.		2³⁄₁₆″	⁵⁄₃₂″	**5674K61**	9.22
5 .... 1¹⁄₈″	Steel	Black-Oxide Steel	180	1²¹⁄₃₂″	2⁷⁄₁₆″ Dia.		2³⁄₁₆″	⁵⁄₃₂″	**5674K63**	9.88
5 .... 1¹⁄₄″	Steel	Black-Oxide Steel	225	1³⁄₄″	2⁷⁄₁₆″ Dia.		2³⁄₁₆″	⁵⁄₃₂″	**5674K64**	10.15
6 .... 1¹⁄₂″	Steel	Zinc-Plated Steel	250	1¹³⁄₁₆″	3″	3″	2¹⁵⁄₃₂″	⁹⁄₃₂″	**5674K2**●	16.16
6 .... 1¹⁄₂″	Nylon	Zinc-Plated Steel	125	1¹³⁄₁₆″	3″	3″	2⁷⁄₁₆″	⁹⁄₃₂″	**5674K22**	34.12
6 .... 1¹⁄₂″	Stainless Steel	Zinc-Plated Steel	250	1¹³⁄₁₆″	3″	3″	2⁷⁄₁₆″	⁹⁄₃₂″	**5674K16**	45.74
6 .... 1¹⁄₂″	Stainless Steel	Stainless Steel	250	1¹³⁄₁₆″	3″	3″	2⁷⁄₁₆″	⁹⁄₃₂″	**5674K24**	65.93
Shock Absorbing—*Furnished with a ¹⁄₄″ thick neoprene mounting pad.*										
6 .... 1¹⁄₂″	Steel	Zinc-Plated Steel	250	2¹⁄₁₆″	3″	3″	2⁷⁄₁₆″	⁹⁄₃₂″	**5674K41**	25.75
6 .... 1¹⁄₂″	Stainless Steel	Stainless Steel	250	2¹⁄₁₆″	3″	3″	2⁷⁄₁₆″	⁹⁄₃₂″	**5674K42**	73.17
Washdown—*With dual-sealed ball and side vents to expel contaminants.*										
7 .... 1″	Stainless Steel	Black Nylon	525	1²⁵⁄₃₂″	3″	3″	2⁹⁄₃₂″	¹⁄₄″	**6617K85**	147.78
Heavy Duty—*With impact-resistant housing.*										
1 .... ¹⁄₂″	Steel	Zinc-Plated Steel	100	⁷⁄₈″	1⁷⁄₈″	1¹⁄₄″	1³⁄₈″	⁵⁄₃₂″	**5674K48**	42.05
8 .... 1″	Steel	Zinc-Plated Steel	500	1⁵⁄₈″	2¹⁄₄″	2¹⁄₄″	1³⁄₄″	⁷⁄₃₂″	**5674K29**	100.80
8 .... 1″	Steel	Zinc-Plated Steel	830	1³⁄₄″	3″	3″	2⁹⁄₃₂″	⁵⁄₁₆″	**5674K37**	144.32
8 .... 1″	Steel	Black-Oxide Steel	705	1²⁵⁄₃₂″	3″	3″	2⁹⁄₃₂″	⁹⁄₃₂″	**5674K68**	191.33
8 .... 1¹⁄₂″	Steel	Zinc-Plated Steel	2,400	2³⁄₈″	3″	3″	2⁹⁄₃₂″	⁵⁄₁₆″	**5674K38**	186.14
8 .... 1¹⁄₂″	Steel	Black-Oxide Steel	2,200	2¹⁵⁄₃₂″	3″	3″	2⁹⁄₃₂″	⁹⁄₃₂″	**5674K71**	235.73

●Not for use in ball-down or angled applications. ♦Not for use in angled applications.

Countersunk Flange-Mount Ball Transfers

Transfers can be used ball up, ball down, or at an angle, unless noted. Temperature range for nylon balls and housings is 32° to 195°F.

Ball Dia.	Ball Material	Housing Material	Cap., lbs.	(A)	(B)	(C)	Flange Size Lg.	Flange Size Wd.	Bolt Holes Ctr.-to-Ctr.	Bolt Holes Dia.		
General Purpose												
9 .... 1″	Steel	Zinc-Plated Steel	75	³⁄₄″	1³⁄₄″	¹⁄₂″	2³⁄₄″	2¹⁄₈″	2³⁄₁₆″	⁷⁄₃₂″	**2415T33**	$8.42
9 .... 1″	Nylon	Zinc-Plated Steel	35	³⁄₄″	1³⁄₄″	¹⁄₂″	2³⁄₄″	2¹⁄₈″	2³⁄₁₆″	⁷⁄₃₂″	**2415T43**	16.43
9 .... 1″	Stainless Steel	Zinc-Plated Steel	75	³⁄₄″	1³⁄₄″	¹⁄₂″	2³⁄₄″	2¹⁄₈″	2³⁄₁₆″	⁷⁄₃₂″	**2415T35**	20.53
9 .... 1″	Stainless Steel	Stainless Steel	75	³⁄₄″	1³⁄₄″	¹⁄₂″	2³⁄₄″	2¹⁄₈″	2³⁄₁₆″	⁷⁄₃₂″	**2415T36**	38.71
11 .... ⁵⁄₈″	Steel	Steel	20	³⁄₈″	3¹⁄₃₂″	³⁄₈″	1¹¹⁄₁₆″ Dia.		1¹⁄₄″	¹⁄₈″	**2415T13**	4.63
11 .... ³⁄₄″	Steel	Zinc-Plated Steel	20	1³⁄₃₂″	1³⁄₁₆″	1⁵⁄₃₂″	2¹³⁄₃₂″ Dia.		1³⁄₄″	⁷⁄₃₂″	**2415T15**▲	7.87
11 .... ³⁄₄″	Stainless Steel	Stainless Steel	20	1³⁄₃₂″	1³⁄₁₆″	1⁵⁄₃₂″	2¹³⁄₃₂″ Dia.		1³⁄₄″	⁷⁄₃₂″	**2415T16**▲	22.68
11 .... 1″	Steel	Zinc-Plated Steel	55	⁹⁄₁₆″	1¹⁄₂″	⁵⁄₈″	2⁷⁄₈″ Dia.		2³⁄₁₆″	³⁄₁₆″	**2415T17**▲	9.11
11 .... 1″	Stainless Steel	Stainless Steel	20	⁹⁄₁₆″	1¹⁄₂″	⁵⁄₈″	2⁷⁄₈″ Dia.		2³⁄₁₆″	³⁄₁₆″	**2415T18**▲	27.37
13 .... ¹¹⁄₁₆″	Steel	Black-Oxide Steel	90	³⁄₄″	¹¹⁄₁₆″	⁵⁄₃₂″	1⁵⁄₁₆″ Dia.		3¹⁄₃₂″	¹⁄₈″	**2415T24**	5.92
13 .... 1″	Steel	Black-Oxide Steel	135	1¹⁄₁₆″	3¹⁄₃₂″	³⁄₁₆″	1²³⁄₃₂″ Dia.		1⁹⁄₃₂″	⁵⁄₃₂″	**2415T25**	6.71
13 .... 1¹⁄₈″	Steel	Black-Oxide Steel	180	1¹⁄₁₆″	3¹⁄₃₂″	³⁄₁₆″	1¹³⁄₁₆″ Dia.		1¹¹⁄₃₂″	⁵⁄₃₂″	**2415T27**	9.29
13 .... 1¹⁄₄″	Steel	Black-Oxide Steel	225	1⁵⁄₁₆″	3¹⁄₃₂″	³⁄₁₆″	2″ Dia.		1¹⁵⁄₃₂″	⁵⁄₃₂″	**2415T31**	10.18
14 .... ¹¹⁄₁₆″	Steel	Black-Oxide Steel	90	³⁄₄″	¹¹⁄₁₆″	⁵⁄₃₂″	¹⁵⁄₁₆″	1⁷⁄₃₂″	¹¹⁄₁₆″, 3¹⁄₃₂″	¹⁄₈″	**2415T21**	6.03
14 .... 1″	Steel	Black-Oxide Steel	135	1¹⁄₁₆″	3¹⁄₃₂″	³⁄₁₆″	1³⁄₈″	1³⁄₄″	1″, 1³⁄₈″	⁵⁄₃₂″	**2415T22**	6.63
14 .... 1¹⁄₈″	Steel	Black-Oxide Steel	180	1³⁄₁₆″	3¹⁄₃₂″	³⁄₁₆″	1³⁄₈″	1³⁄₄″	1″, 1³⁄₈″	⁵⁄₃₂″	**2415T23**	9.29
Shock Absorbing—*With spring-loaded ball; maximum deflection is ¹⁄₄″ @ 65 lbs. load.*												
12 .... 1″	Steel	Zinc-Plated Steel	125	¹⁄₂″	1¹¹⁄₁₆″	¹⁵⁄₁₆″	3¹⁄₈″ Dia.		2³⁄₈″	³⁄₁₆″	**2415T11**●	30.39
12 .... 1″	Stainless Steel	Stainless Steel	125	¹⁄₂″	1¹¹⁄₁₆″	¹⁵⁄₁₆″	3¹⁄₈″ Dia.		2³⁄₈″	³⁄₁₆″	**2415T48**●	67.55
Washdown—*With dual-sealed ball and side vents to expel contaminants.*												
15 .... 1″	Stainless Steel	Black Nylon	525	¹⁄₂″	2″	1¹⁄₄″	3″	3″	2⁹⁄₃₂″	¹⁄₄″	**6617K84**	130.33
Heavy Duty—*With impact-resistant housing.*												
10 .... ¹⁄₂″	Steel	Zinc-Plated Steel	100	⁵⁄₁₆″	¹⁵⁄₁₆″	⁵⁄₈″	1⁷⁄₈″	1¹⁄₄″	1³⁄₈″	⁵⁄₃₂″	**2415T81**	41.26
16 .... 1″	Steel	Zinc-Plated Steel	500	¹⁵⁄₃₂″	1³⁄₄″	1⁵⁄₃₂″	2¹⁄₄″	2¹⁄₄″	1³⁄₄″	⁷⁄₃₂″	**2415T82**	106.95
16 .... 1″	Steel	Zinc-Plated Steel	830	¹⁄₂″	2″	1¹⁄₄″	3″	3″	2⁹⁄₃₂″	⁵⁄₁₆″	**2415T79**	140.48
16 .... 1″	Steel	Black-Oxide Steel	350	¹⁄₂″	2″	1¹⁄₄″	3″	3″	2⁹⁄₃₂″	⁹⁄₃₂″	**2415T52**▲	175.98
16 .... 1¹⁄₂″	Steel	Zinc-Plated Steel	2,400	1″	2³⁄₈″	1³⁄₈″	3″	3″	2⁹⁄₃₂″	⁵⁄₁₆″	**2415T84**	199.67

▲Capacity is approximately twice as high when used in the ball-up position. ●Not for use in ball-down or angled applications.

McMASTER-CARR®

MOBILE PLATFORM MANUFACTURING TIME ESTIMATES

MANUFACTURING / ASSEMBLY PROCESS	Est. Time [min]	Quantity [-]	Subtotal [min]	[hr]
DESIGN 1				
retrieve pre-cut pieces of 80/20 off shelf	5	5	25	0.4
mark & cut remaining 80/20 on bandsaw	7.5	2	15	0.3
manufacture motor mount (like course example)	72	2	144	2.4
manufacture wheel hub (like course example)	205	1	205	3.4
modify wheel hub made earlier in the semester	20	1	20	0.3
assemble 80/20 frame	5	1	5	0.1
attach motor to motor mount	7.5	2	15	0.3
attach motor mount to robot frame	5	2	10	0.2
attach wheel hub to motor	8.5	2	17	0.3
attach wheel to wheel hub	8.5	2	17	0.3
attach caster wheel to robot frame	10	1	10	0.2
attach and wire control box for first time	20	1	20	0.3
TOTAL:			**503**	**8.4**
DESIGN 2				
…	…	…	…	…
TOTAL:			**…**	**…**
DESIGN 3				
…	…	…	…	…
TOTAL:			**…**	**…**
DESIGN 4				
…	…	…	…	…
TOTAL:			**…**	**…**
DESIGN 5				
…	…	…	…	…
TOTAL:			**…**	**…**

EML2322L Time Estimation for Part Manufacturing

Part Name / Number: EXAMPLE MOTOR MOUNT BRACKET

MANUFACTURING PROCESS	Student Experience Level	
	BEGINNER [min]	INTERMEDIATE [min]
mark & cut 3/16" x 2.5" bar stock on bandsaw	10	8
load part(s) into milling machine vise	5	3
find X, Y zeros using edgefinder	10	8
drill (3) clearance holes for motor mounting, thru	20	15
drill (2) clearance holes for bracket mounting, thru	15	10
time to debur part between steps	5	3
time to clean machine when finished	7	5

ESTIMATED MANUFACTURING TIME:	[min]	72	52
	[hr]	1.2	0.9

NOTE: these times are estimates based on relative student experience;
ask a TA if any of the estimates don't seem reasonable.

EML2322L Time Estimation for Part Manufacturing

Part Name / Number: WHEEL HUB

MANUFACTURING PROCESS	Student Experience Level	
	BEGINNER [min]	INTERMEDIATE [min]
mark & cut 2" dia. bar stock on bandsaw	12	7
load part and cutting tool into lathe	8	5
face first end of part	5	3
turn main shoulder on part	35	20
cut chamfers on front (2) edges of part	5	3
mark & cutoff part to ~1.6" on bandsaw	12	7
reload part into lathe and face second end of part	7	5
drill and ream precision 5/16" center hole, 1.5" deep	25	15
load part and drill chuck into mill	8	6
find X, Y zeros using edgefinder	10	8
drill and tap (3) 10-24 threaded holes, 0.5" deep	30	25
turn part 90-deg and reload into vise	3	2
find X, Y zeros using edgefinder	10	8
drill and tap (2) 10-24 threaded hole, 0.5" deep	20	15
misc. time to debur part between steps	5	4
time to clean machines when finished	20	16

ESTIMATED MANUFACTURING TIME:	[min]	215	149
	[hr]	3.6	2.5

NOTE: these times are estimates based on relative student experience;
ask a TA if any of the estimates don't seem reasonable.

Mobile Platform Testing Evidence/Explanation

Figure 1: Entstort with 8" Wheels

Figure 2: Denso with 6" Wheels

Testing Procedure

Controllability testing was performed on two provided mobile platforms. Both platforms used a three-wheel, differential steering style of driving; as per the *Background Research*, this style of platform was chosen as the most viable for this project because … . One platform was initially outfitted with two Entstort 44rpm right-angle gear motors and 8″ drive wheels as shown above in *Figure 1*. The platform was driven around a series of buckets (as shown in *Figure 3* …) on multiple runs with 8″, 10″ and 13.6″ drive wheels on each respective run.

The same test was performed with a second platform, initially outfitted with Denso 150rpm right-angle gear motors and 6″ wheels. The wheel choices tested on the Denso motor platform included 4″, 6″ and 8″ wheels.

Based on the results of the testing (presented in Table 1 …) we were able to conclude …).