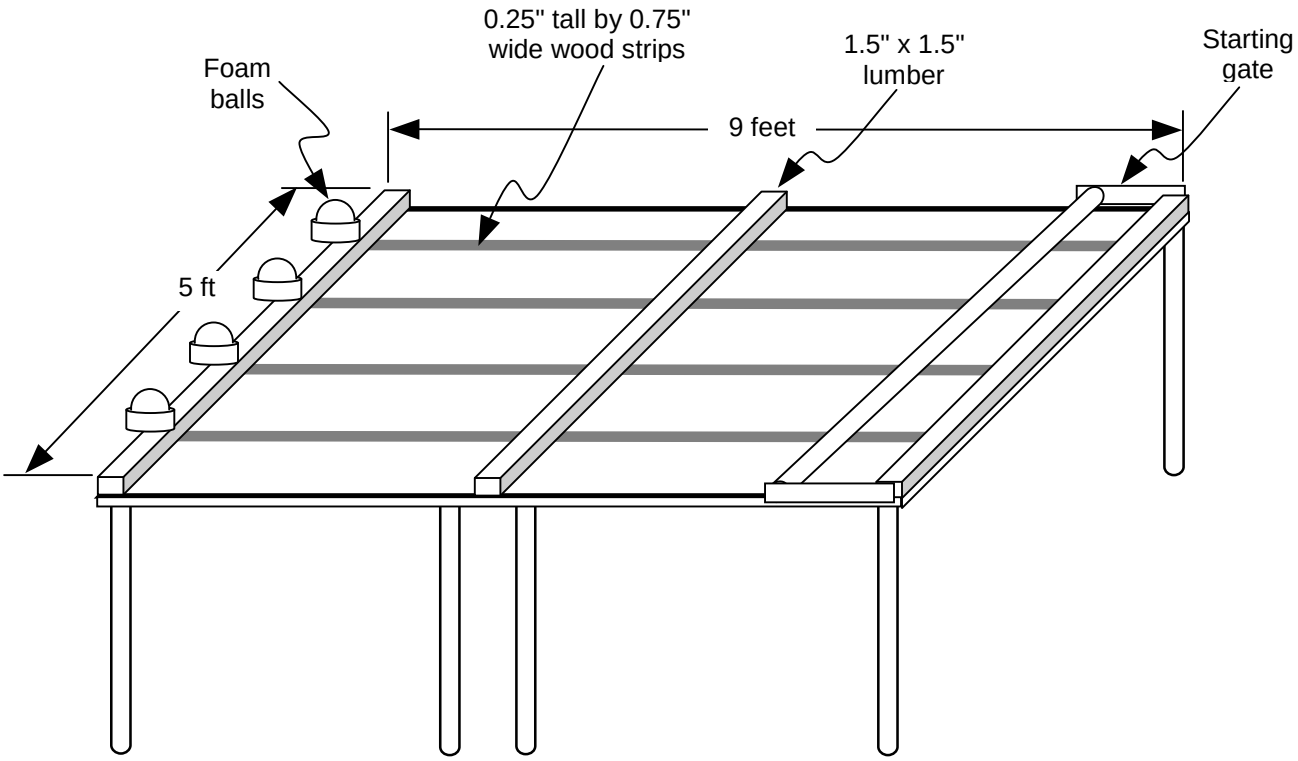
MECH 202 Spring 2012 Competition Project – Updated 3 April 2012
"Foam Ball Rescue" (Preliminary Description)

Your team is to design, fabricate, assemble and compete with a device that safely retrieves a 4-inch diameter foam ball from the opposite side of a 9-foot ping-pong table as well as satisfying the competition rules below. The MECH202 TA's are the "Judges of the Competition." Bob Thilmont and Bert Vermeulen will act as Chief Judges. Your team must also submit a report detailing your device and the process used to develop your design.

The Time
Saturday, April 21 starting at 10am in Eng 100. You should plan for this to take most of the day.

Competition Overview
1. The objective is to be the first team (of up to four in each round) to safely retrieve a foam ball and return back to the starting zone.

2. Below is a conceptual (not to scale) drawing of the fixture.



3. The TA's will keep this fixture locked, except during viewing times from now until race day. Your team should schedule with them to see and measure the fixture to ensure that your device will work correctly on it. You are not allowed to place your device on the competition fixture until the first time you compete on April 21.

Competition Details

4. At the start of each round, devices will be placed on one of four lanes on the fixture. At the starting time your device can be a maximum of 10 inches measured in the direction of travel. There is a starting gate approximately 13 inches from the starting end of the fixture. At the start of the round your device may only touch the starting gate. Touching the block at the starting end of the table prior to having retrieved and returned with the foam ball will result in a disqualification for that round.

5. The tasks your device must perform (in time-sequential order) are:
   a. The entire device must move past the barrier (a 1.5x1.5 inch piece of lumber) halfway from the starting end and the foam ball;
   b. The device must then pick up the foam ball; and
   c. The entire device must then return back onto the starting end of the table and press the micro-switch in your lane signaling that your device has returned. Appendix D shows the approximate location of the micro switches for each lane.

6. At no time during a round should any part of your device extend more than 12 inches above the surface of the table or more than 5.5 inches on either side of the 0.75" wide wood strip in the center of your lane. This creates a 11.75-inch wide by 12-inch tall envelope within which your device must stay. Note that this gives a clearance of only 10.5 inches above the center 1.5x1.5 inch lumber.

7. You must place your device on the fixture in the starting area and step away. Your device must use the opening of the starting gate as its signal to move forward.

8. Once the starting gate has opened, your device can enlarge itself in a direction parallel to the 0.25" tall by 0.75" wide wood strips ~~bungee~~, so long as it stays a single device. The fact that it must stay as a single device means that you cannot use remote control (a remote control would make it not a single device). Note that the entire device must move past the barrier halfway to the foam ball and the maximum width and height of your device can never exceed the dimensions provided in #6.

9. Each round of the contest is 45 seconds long. At the end of the round, the devices will preferably be stopped or stop themselves.

10. Safety is paramount. Any device that detaches from the foam ball after making contact or damages the foam ball will be completely eliminated from the competition. In the real world, that device would not be able to get insurance after causing a fatality.

11. If more than one device in a round safely accomplishes all tasks identified in #5 ~~#4~~, and does not violate any other rules, the device that completes all tasks first will be declared the winner of that round. Other devices will be ranked based on the time when they finish (within the 45 seconds) or how many of the tasks they accomplish as described below.

12. If only one device safely completes all of the tasks identified in #11, and does not violate any other rules, that device will be declared the winner of that round. Other devices will be ranked based on how many of the tasks they accomplish.
    a. As mentioned in #10, devices that cause a foam ball fatality are ranked lowest and eliminated.
    b. Devices that came apart, touched the block at the starting end prior to retrieving the foam ball as described in ~~#4~~ #5, or moved outside of the boundaries defined in #6 are ranked next lowest.
    c. Devices that met none of the tasks listed in #5 will be ranked next lowest and will be ranked based on the distance moved by the furthest back part of the device.
    d. Devices that safely picked up the foam ball, but did not return completely to the starting zone will be ranked highest (but below fully successful devices), based on the distance between the foam ball and the starting zone at the end of the 45-second period.
    e. In case of a tie based on the above criteria, the lightest device will be judged to be superior.

Other Rules and Information

13. Other than teams that are eliminated due to a foam ball fatality as defined in #10, the competition will be "double elimination" so each team will have at least two chances to participate. Details of how the heats and how the winners and losers move from round to round will be available prior to the day of the competition. Only the first place winners will advance to the next round.

14. Your device cannot touch any of the fixture except:
    a. the starting gate at startup;
    b. the table surface and 3/4 inch lane strip;
    c. the 1.5 x 1.5 inch lumber in the middle of the table between the starting and foam ball ends;
    d. the region of the opposite side of the table where the foam ball is to be picked up; and
    e. the starting area after returning with the foam ball.
    No part of your device should not intentionally touch any other device during the competition. If we can see that this contact with another device was intentional, your device will be eliminated.

15. Your device can weigh no more than 1 lb.

~~16.~~ You are encouraged to build your own test fixture. We deliberately made our fixture from standard low cost parts to facilitate duplication of the key elements for our testing. ~~We will be providing a parts list by March 19.~~ There is a parts list provided in Appendix B.

17. Keep in mind that the components used to make the competition fixture will not be perfect or exactly like a test fixture that you might fabricate from the same parts. It is important that your device can tolerate these types of differences. This is part of having a robust design.

18. Your device can be made from any materials that you would like to use. However, you cannot use any energy storage method or device that might be deemed hazardous. Examples of hazardous energy storage devices include, but are not limited to:
    - Explosives, combustion processes, or highly exothermic reactions (such as model rockets).
    - A compressed fluid that might release too quickly
    - Anything deemed to be unnecessarily harmful to either the fixture or another competitor's device. This includes having motors that overheat, generate sparks, etc or wheels that leave a residue on the table or wood strips.

    The TA's will serve as "OSHA" safety inspectors. You will need their certification from a safety inspector before noon on Friday, April 20. It is in your interest to contact the safety inspectors early to ensure that you do not waste time on a device that may not be certifiable.

19. If your team is not willing to stand next to your device without protective clothing or safety glasses, your device will be considered hazardous! However, since some individuals are braver than others. The judges reserve the right to deem a device hazardous.

20. No human contact with the device is allowed at any time during the time from the start of a round until that round has finished.

21. The device cannot contain any biological components. For example, you are not allowed to employ a trained squirrel to retrieve the foam ball.

22. The foam balls used in the competition will be supplied by us. You cannot choose which foam ball your team will retrieve or make any modifications to the foam ball. You also cannot choose which lane your device will run in.

23. The foam balls we use are 4" in diameter and come from Wal-Mart. They go under the name Poof Balls, cost $0.99, and come from Poof-Slinky Inc in Plymouth, Michigan (www.poof-slinky.com). The bar code is 0-83568-02400-8.

24. Electric motors. In the past a high percentage of devices have used electric motors. This is fine, but can run up the cost and weight of your device. We have tried deliberately to try to keep the cost of this competition as low as possible. We encourage teams to come up with elegant low-cost ways to meet the requirements that do not require motors. We have also obtained a supply of 6V DC motors with reduction gears. There is one of these motors available for any team that would like one. Appendix C provides the specs for these motors. They appear to weigh about 2 ounces.

25. ANY intentional attempt to damage the opponent in lieu of meeting the objectives of the competition will be grounds for disqualification. In the case of destruction deemed by the judges to be accidental, but severe enough to unfairly influence the competition's outcome the judges may permit repairs and a rematch.

26. Can your device disrupt other devices? No, you would forfeit that round if the disruption was judged to be intentional. The round would be rerun if it were judged to be accidental. If it accidentally occurred in two successive runs, you would be disqualified even if it were unintentional.

27. Each round will have a maximum of five minutes for you to place your device onto the fixture, move away prior to the start, compete and remove the device from the fixture

28. Your team must check into the registration table 15 minutes prior to your round. Failure to do so will result in a forfeit for that round. Once your round is complete you will need to track your team's placement on the bracket sheet and note the time of your next competition. You will be responsible to be ready on time for subsequent rounds based on the brackets you are assigned. If you fail to show up to your respective round you will forfeit that round.

29. Damaging the fixture. Your team will be disqualified if your device intentionally or unintentionally damages the fixture in any manner including but not limited to: breaking any part of the fixture, generating noticeable nixes or notches that will impact the integrity of the competition, adding foreign substances such as oil or lubricants onto the fixture.

30. Protests. All protests must be registered immediately after the competing round. You must qualify your protests based on the ground rules and the project definition. Keep good engineering records (engineering book) of your development process to use to defend your positions. If you have no supporting documentation at the day of the competition, your protest will be disallowed. Bert Vermeulen will be the final judge on all protests.

31. And keep in mind. This competition is a lot of fun and an opportunity to cheer and encourage everyone. Feel free to invite your friends and family as well. You can see elements of last three year's competitions at www.mech202.com.

32. Can we use a spring? There's no problem in using a spring, rubber band, or other means of propulsion as long as it does not generate so much force as to be dangerous. Using a crossbow, for example would be considered dangerous because we don't think any of your team members would feel safe standing in front of it.

33. Can we grab our device after it completes the task? Not until the round has been declared completed. Please ensure that your device cannot fall of the table, damage itself, or spin its wheels in a way that will damage the table or generate excessive heating.

34. Will there be any changes made to the competition fixture prior to April 21? We may make minor improvements to ensure that the fixture is stable and race worthy. These changes may slightly affect the geometry of the fixture and the starting gate, but not alter any of the fundamental functionality.

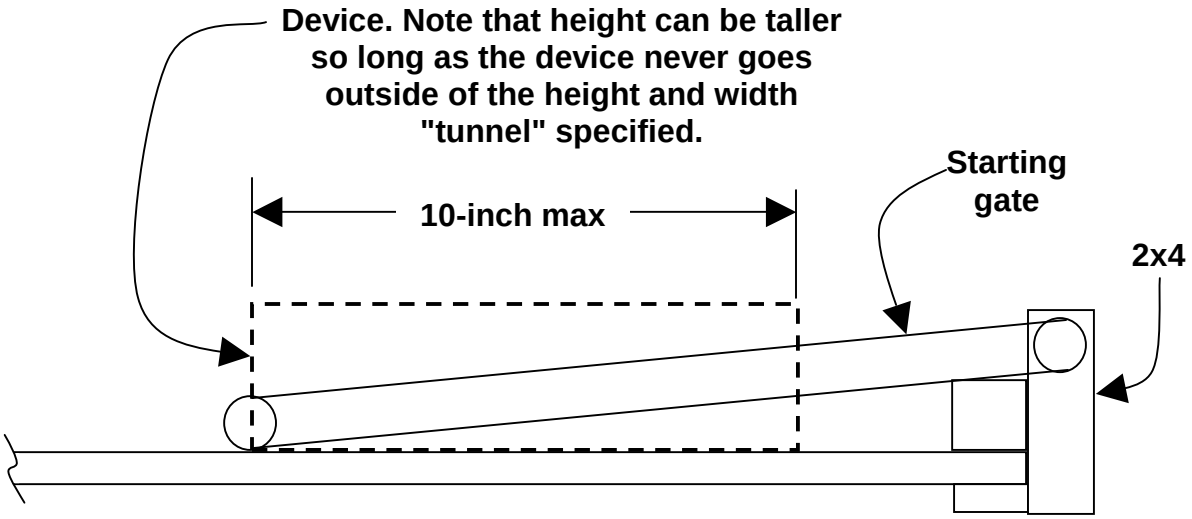
Frequently asked questions that may be of interest to all groups (Added 2 April 2012)

35. How do you define damage to the foam ball? If your device makes any permanent change to the ball, we would consider this to be damage. Examples include:
- Parts of the ball breaking off and sticking to an adhesive or other part of your device;
- Parts of any adhesive (or paint) sticking to the ball or to your device;
- Overheating of the ball so that some of it melts, singes, or burns; or
- Any device that penetrates the surface of the ball by making any cuts or holes in the foam.

36. We noticed that the table wobbles and the 1/4" by 3/4" wood strip is not fastened. Will it be the same on race day? Yes, you should design your device to be tolerant of table and guideway wobble.

37. Will the screws in the white cups that hold the foam balls be sticking up? No, they will be flush with the bottom of the cups so the foam balls will sit inside the cups.

38. Can you give more of a definition of where our device can sit relative to the starting gate at the beginning of each round? Below is a sketch of the geometry and regions that your device can occupy at the beginning of the round. Note that your device can (and probably should) touch the starting gate in order to be able to start, since you will not be near your device and remote control is not allowed.



39. How do you define stopping of the vehicle at the end of the round? Can the motor keep running? When the round finishes, it may be several minutes before you can remove your device from the fixture. During that time, there may be damage the table if your motor continues to turn and the wheels keep spinning, or the motor overheats. While it is not an absolute requirement that your device turn itself off, it is important that you design your device not to damage anything.

40. Can we grab our device if it tries to go off the table? You will be too far away from the fixture during the round to be able to do this. Please design your device (a) not to stray from the course and (b) not to damage itself if it flies off. You should also plan to have spares in case your device does damage itself and needs to be repaired between rounds.

41. How is the 10-inch length for our device determined? We measure and weigh every device at check-in. We reserve the right to recheck it at other times during the competition.

42. Would adding sandpaper to our wheels be considered damaging to the table? If we can see any scratches caused by your device on the table, we would consider this as damaging. Abrasives are not a good idea.

Judges Decisions Disclaimer
In a competition of this nature it is hard to anticipate all the interpretations of the rules and situations that will arise in the competition. Therefore, the judges will decide anything not covered by these rules and the interpretations of these rules. These rules are subject to optimization, and may be altered by the staff to preserve the "spirit" of the contest**.**

The Rewards
1. The winning team will receive an A for the course and will not have to take the final examination
2. The 2nd place team will receive an A for the project and a 100 for the final
3. The 3rd place team will receive an A for the project

Note that all three winning teams must be present during the lecture on April 24, as we may ask you to help explain to others in the class how you designed your device and some of its more successful features.

We will ask other faculty members to help judge the devices for other areas of merit, which might include:

- Manufacturing craftsmanship.
- The use of mechatronics.
- Design simplicity and elegance
- Low cost

The Lead Up
Your design group may ask any questions whatsoever of Bob Thilmont, Bert Vermeulen or the TAs. This is strongly encouraged to ensure that your device meets the spirit of the competition. We encourage you to use RamCT to ask these questions. If you email questions to us, these questions and their answers will be posted on RAMCT. If you have any of us sign a "non-disclosure agreement" (sample attached), we will then discuss with you confidentially those issues you have, and will not disseminate your questions or the answers to the entire class.

Required Report
If you did not get one of the top three places in the competition, your grade for this project will be based almost entirely on the report that you submit, with the following clarifications:

A. Your competition outcomes will not affect the grade of the report unless you place in one of the top 3 positions.

B. We reserve the right to lower your grade for the project if we feel that you did not make a serious effort to build a device capable of meeting all of the tasks stated in #5 above.

The report will be turned in at the time of the competition, the first time your device runs on the fixture. Please bind the report in a professional manner and also put an electronic (PDF) version of the report into the Drop Folder prior to 9AM on Saturday, April 21. The paper version must be in before 10am on the day of the competition. The report will consist of:

Page 1 (Cover sheet):
- Names and contact emails for each member of your group
- A title identifying the device
- A photo of the device to fit in the remainder of the space of page 1

Report:
1. A project plan and documentation showing the relationship between actual completion of project tasks versus plan. This needs to include an estimate of the hours spent by each team member on the project.

2. Documentation showing the process used to develop the specification for your device.

3. The specification you designed the device to meet. This should be in your own words, drawings, charts, equations, etc. It can use material provided in this document but should include other items that you thought were relevant. Your specification should attempt to quantity as much as possible using measurements that can later be verified. Please include how you prioritized the musts and wants in your specification.

4. An engineering analysis of the physical and technical challenges the device needed to overcome.

5. A description of the design alternatives you considered and the process used to make the design decisions needed to make to address the physical and technical challenges your team identified.

6. A set of drawings that show how your device functions. These don't need to be Pro/E drawings and they don't need all details. There needs to be text to accompany these drawings that explains the illustrations in sufficient detail so that anyone "skilled in the art" (i.e. another student in this class) could buy the necessary components and fabricate a device that functioned similarly to your device. This section should include a bill or materials that lists the cost of each item required to fabricate your device and where this item might be obtained.

7. A description of testing that you did to verify that your device would perform well in the competition. This should include a description of things you learned during these tests and improvements that you made as a result of testing.

8. A safety analysis of your design or design choices showing risks and what your team did to minimize the most critical hazards.

9. A reliability analysis of your design or design choices showing the places where you believe your device is most likely to fail and what you have done to build design margin into those areas.

10. A service and support plan for your device in case any part of your device should fail and you need to make emergency repairs during competition day.

Post Mortem

By Monday evening April 23 (at 6pm), all groups including those that won first, second, or third place should turn in brief post-mortem listing five – ten things they learned from the competition. Doing a post-mortem is a good idea for any project. This will also be part of your grade for the project. More details of the content of the post-mortem will be provided prior to the due date.

APPENDIX A.

Request for Confidentiality (use if you need to share info with TA's or Instructors)

The undersigned agrees to hold confidential information of a competitive nature with the group members listed here. If the discussion leads to items of general interest (eg. – rules, competition or grading clarification), the design group allows publication of those items of general interest. Otherwise, any discussion of a competitive nature leading to a competitive advantage for the group will be held confidential.

Signed: Dated:

APPENDIX B. Fixture Parts List

1. **Ping pong table.** We are using a regulation ping-pong table that is standard width and height and has a standard surface on it. The one we are using was purchased at Sports Authority and was a pretty basic model costing less than $200.

2. The **lumber on the surface of the table** at both ends of the table and in the middle is standard 2"x2" lumber, which means these wood pieces are approximately 1.5" by 1.5" in cross section. These three blocks span the entire 5-foot width of the table.

3. There are 1"x2" (which means they measure 1.5" by 0.75 inch) lumber strips on the bottom of the table directly underneath the 2x2 lumber on each end of the table. These two strips are also 5 ft long.

4. There is a 2"x4" inch (which means 1.5" by 3.5" piece of lumber on the back part of the starting area. This can be seen on page 5.

5. The guide ways are made of 1/4" x 3/4" wood. These run the entire 9 foot length of the table and our fixture uses four of them.

6. The holders for the foam balls are made from 4" inside diameter plastic plumbing end caps.

7. We currently use a pair of 4" C-clamps to hold the central 2x2 bar onto the table.

8. The starting gate is made of 3/4" inside diameter (approximately 1" outside diameter) rigid PVC tubing. There are elbows used for the corners and t-joints to make a handle. These pieces will be solvent bonded together immediately prior to the competition.

9. The foam balls are described in #23 above.

10. The micro switches are purchased at Radio Shack. They are part number 275-0116 and described as being SPDT-Submini Lever Switches.

11. The micro switches are sandwiched between two 1/8" x 3/8" aluminum bars (4 foot in length) in the configuration shown in Appendix D.

12. There are a pair of 1/4" high spacers between the two aluminum bars and another pair between the aluminum bar and the 2x2 (actually 1.5 inch x 1.5 inch) lumber that it is mounted to at the starting gate as shown in Appendix D.

13. There is a variety of hardware (screws and bolts) used to hold each of the pieces together. The specifics of the hardware used should not be critical to fabricating your fixture. In general, we have tried to ensure that this hardware is not exposed in the region your device should be operating.

APPENDIX C. Electric Motors

An anonymous donor has contributed small DC motors to the Mechanical Engineering department for use on student projects. We have enough motors to give each team one motor that they can use for their second project. The motors operate at 6V and include a reduction gear that provides a speed of about 90 RPM at 6V no load.

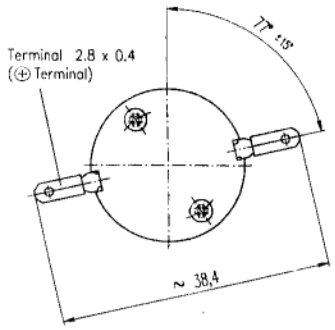
Each team is entitled to 1 motor. If you burn it out, there's no spare and the motors themselves are pretty pricey to buy.

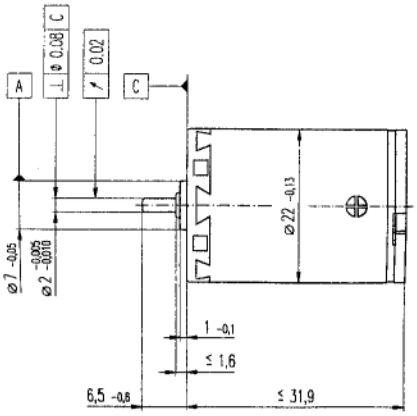
We don't necessarily recommend that you use an electric motor for your second project. You'll need to do your analysis to determine whether to use an electric motor and whether this would be the motor that you want to use. Remember that the heavier your device, the more the bungee will sag. We haven't weighed them, but the motors appear to be about 2 ounces.. If you decide to use one of these motors, please include your engineering analysis of why you chose to use this motor.

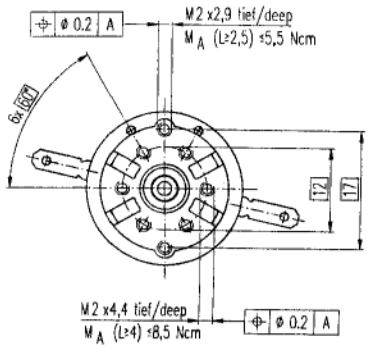
The motors can be picked up in the TA's office.

The next two pages provide the specs on the motor. It is a Maxon 110117. The reduction gear appears to be a spur gear. Based on measurements made, we believe the spur gear is either providing a 64:1 or a 131:1 reduction.

A-max 22 ∅22 mm, Precious Metal Brushes CLL, 5 Watt, CE approved







M 1:1

Stock program
Standard program
Special program (on request)

Motor Data			Order Number		
			110117	110119	110120
	Values at nominal voltage				
1	Nominal voltage	V	6.0		
2	No load speed	rpm	9640		
3	No load current	mA	29.6		
4	Nominal speed	rpm	7480		
5	Nominal torque (max. continuous torque)	mNm	4.81		
6	Nominal current (max. continuous current)	A	0.840		
7	Stall torque	mNm	21.5		
8	*Starting current*	A	3.65		
9	*Max. efficiency*	%	83		
	Characteristics				
10	Terminal resistance	Ω	1.64		
11	Terminal inductance	mH	0.106		
12	Torque constant	mNm / A	5.90		
13	Speed constant	rpm / V	1620		
14	Speed / torque gradient	rpm / mNm	452		
15	Mechanical time constant	ms	19.1		
16	Rotor inertia	gcm²	4.04		

Specifications

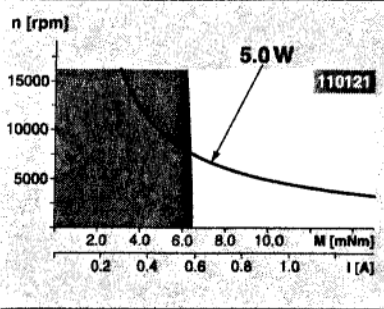
	Thermal data	
17	Thermal resistance housing-ambient	20 K / W
18	Thermal resistance winding-housing	6.0 K / W
19	Thermal time constant winding	10.1 s
20	Thermal time constant motor	540 s
21	Ambient temperature	-30 ... +65°C
22	Max. permissible winding temperature	+85°C
	Mechanical data (sleeve bearings)	
23	Max. permissible speed	16000 rpm
24	Axial play	0.05 - 0.15 mm
25	Radial play	0.012 mm
26	Max. axial load (dynamic)	1 N
27	Max. force for press fits (static)	80 N
28	Max. radial loading, 5 mm from flange	2.8 N
	Mechanical data (ball bearing)	
23	Max. permissible speed	16000 rpm
24	Axial play	0.05 - 0.15 mm
25	Radial play	0.025 mm
26	Max. axial load (dynamic)	3.3 N
27	Max. force for press fits (static)	45 N
28	Max. radial loading, 5 mm from flange	12.3 N
	Other specifications	
29	Number of pole pairs	1
30	Number of commutator segments	9
31	Weight of motor	54 g

CLL = Capacitor Long Life

Values listed in the table are nominal.
Explanation of the figures on page 49.

Option
Ball bearings in place of sleeve bearings
Pigtails in place of terminals
Without CLL

Operating Range



Comments

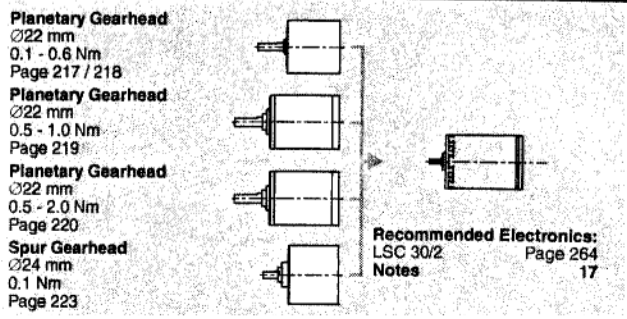
Continuous operation
In observation of above listed thermal resistance (lines 17 and 18) the maximum permissible winding temperature will be reached during continuous operation at 25°C ambient.
= Thermal limit.

Short term operation
The motor may be briefly overloaded (recurring).

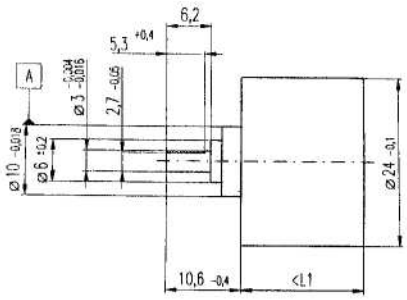
Assigned power rating

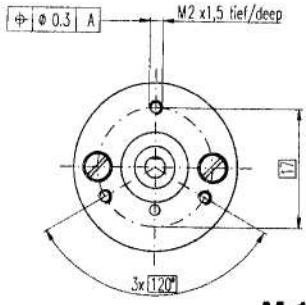
maxon Modular System

Overview on page 17 - 21



Spur Gearhead GS 24 ∅24 mm, 0.1 Nm





M 1:1

Technical Data

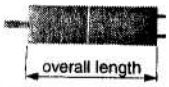
Spur Gearhead	straight teeth
Housing	plastic
Output shaft	stainless steel, hardened
Bearing at output	sleeve bearing
Radial play, 8 mm from flange	max. 0.038 mm
Axial play	0.03 - 0.30 mm
Max. radial load, 8 mm from flange	5 N
Max. permissible axial load	8 N
Max. permissible force for press fits	500 N
Average backlash no load	< 2.5°
Recommended input speed	< 4000 rpm
Recommended temperature range	-20 ... +100°C
Extended area as option	-35 ... +100°C

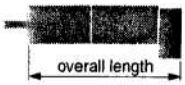
maxon gear

Stock program
Standard program
Special program (on request)

Gearhead Data		Order Number 110480	110481	110482	110483	110484	110485	110486
1 Reduction		7.2 : 1	20 : 1	32 : 1	64 : 1	131 : 1	199 : 1	325 : 1
2 Reduction absolute		93/13	121915/6153	151613/4656	837/13	212629/1625	778642/3909	1093365/3362
3 Max. motor shaft diameter	mm	2	2	2	2	2	2	2
4 Number of stages		2	4	4	4	4	6	6
5 Max. continuous torque	Nm	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6 Intermittently permissible torque at gear output	Nm	0.15	0.15	0.15	0.15	0.15	0.15	0.15
7 Sense of rotation, drive to output		=	=	=	=	=	=	=
8 Max. efficiency	%	81	66	66	66	66	53	53
9 Weight	g	25	28	28	28	28	30	30
10 Average backlash no load	°	1.0	2.0	2.0	2.0	2.0	3.0	3.0
11 Mass inertia	gcm²	0.008	0.01	0.008	0.007	0.006	0.008	0.006
12 Gearhead length L1*	mm	13.7	17.4	17.4	17.4	17.4	21.2	21.2

*for A-max 19 is L1 + 2.8 mm

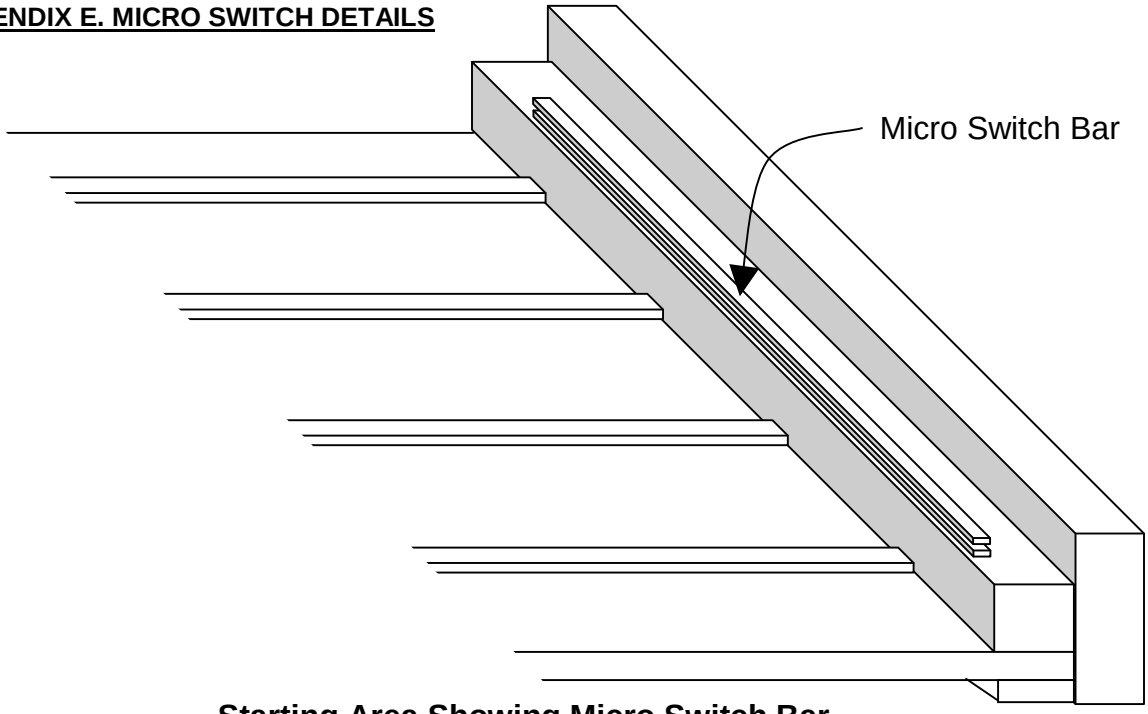




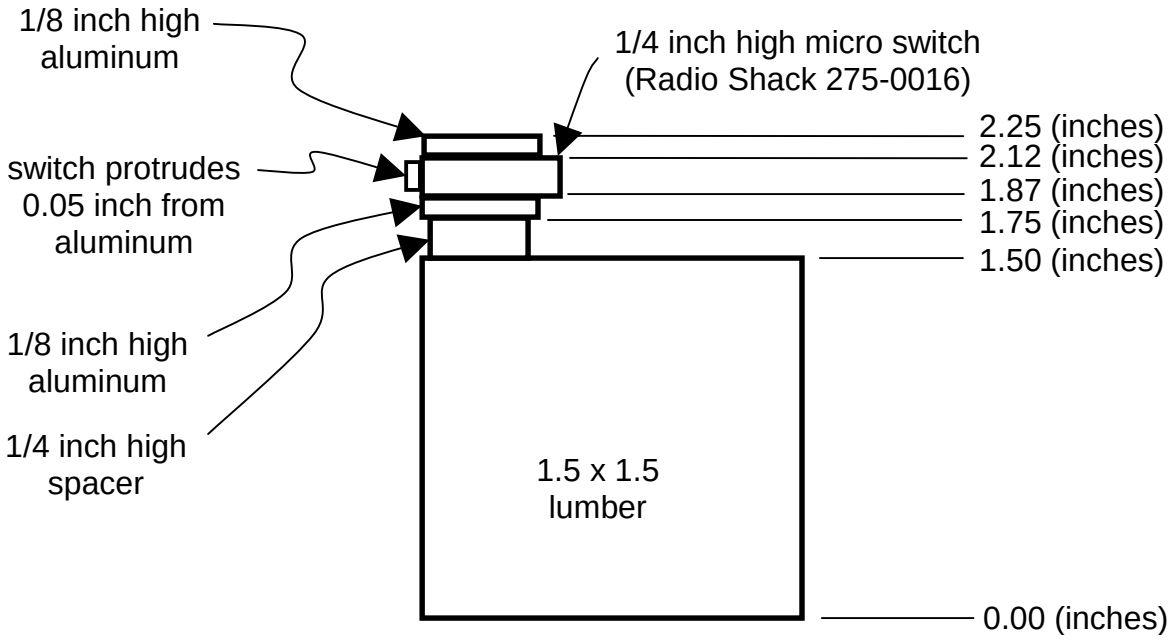
Combination

+ Motor	Page	+ Tacho / Brake	Page	Overall length [mm] = Motor length + gearhead length + (tacho / brake) + assembly parts						
A-max 19	105/106			45.5	49.2	49.2	49.2	49.2	53.0	53.0
A-max 19, 1.5 W	106	MR	243/244	50.6	54.3	54.3	54.3	54.3	58.1	58.1
A-max 19, 1.5 W	106	Enc 22	249	59.9	63.6	63.6	63.6	63.6	67.4	67.4
A-max 19, 1.5 W	106	MEnc 13	258	53.0	56.7	56.7	56.7	56.7	60.5	60.5
A-max 19	107/108			48.1	51.8	51.8	51.8	51.8	55.6	55.6
A-max 19, 2.5 W	108	MR	243/244	52.4	56.1	56.1	56.1	56.1	59.9	59.9
A-max 19, 2.5 W	108	Enc 22	249	62.5	66.2	66.2	66.2	66.2	70.0	70.0
A-max 19, 2.5 W	108	MEnc 13	258	55.6	59.3	59.3	59.3	59.3	63.1	63.1
A-max 22	109-112			45.7	49.4	49.4	49.4	49.4	53.2	53.2
A-max 22	110/112	MR	243/244	50.7	54.4	54.4	54.4	54.4	58.2	58.2
A-max 22	110/112	Enc 22	249	60.1	63.8	63.8	63.8	63.8	67.6	67.6
A-max 22	110/112	MEnc 13	258	52.8	56.5	56.5	56.5	56.5	60.3	60.3

APPENDIX E. MICRO SWITCH DETAILS



Starting Area Showing Micro Switch Bar
(Starting gate removed for clarity)



Detailed End View of Micro Switch Bar
and Mounting to 1.5x1.5 Inch Lumber