MACHINETRON
DEFENDERS OF THE WORK CELL

Description, Rules and Procedures v0.3 20190328

Task Description

MACHINETRON defends known space against the dangers of rampaging raw material. Only by processing deadly raw Florist Foam into safe finished parts can the threat against civilisation be stopped. MACHINETRON is formed by combining four constituent robotic submachines: Handler, Mill, Lathe and Drill. Each robot is a powerful tool to fight evil, bringing its own unique capability. Together, the submachines make MACHINETRON stronger than the sum of its parts.

You must build the four submachines that combine to form MACHINETRON. Each will connect with its fellow submachines, mounted together on a standard base panel in order to cut Florist Foam into prescribed shapes. The shapes will be given in the form of 3D STL files and accompanying 2D three-view drawings. Control data shall be fed into the Handler submachine, and through data connections, it will distribute motion control paths to the other machines. Thus, regardless of the number of students in a team, one team member from each team must build a Handler. Teams with less than four members may forgo building a Drill submachine; teams with less than three members may also forgo building a Lathe submachine.

The Handler shall consist of a central control unit, with a “GO” button. The Mill submachine shall use a 10 mm diameter by ~~30~~ 60 mm long end-mill. The Lathe shall consist of a non-rotating tool with a rectangular cutting head 3 mm wide, ~~20~~ 60 mm deep. The Drill shall consist of a 6 mm diameter by ~~60~~ 80 mm long drill bit. Each machine may have only three actuators, including the tool spindle as appropriate. Connections between submachines shall consist only of four electrical wires: power, ground, and two data lines. There shall be no direct physical link between machines: they are rigidly fixed with respect to each other only through the baseplate.

All-up system testing will occur during scheduled demonstration sessions in week 13. There will also be incremental demos in weeks 7, 9 and 11, allowing partial functionality to be demonstrated. Be aware that this project specification **will** be updated through the course of the semester, with at least one guaranteed project specification change, requiring your design to be flexible to accommodate changes.

Testing Procedure

During testing, teams shall be given one-third of a standard-size (76.6 mm x 110 mm x 80 mm) florist foam and drawings and an STL file for a part to machine from it. Once the part is fitted and secured into the Handler, code is loaded and the GO button is pressed, the machine must operate entirely autonomously to cut the part. Points shall be scored for correctly machining the shape, and the precision to which it is cut. Additional points shall be scored for each additional copy made, further points may be gained by opting to machine a different subsequent part as directed by the adjudicator. Teams may continue to machine parts until they run out of time. For bonus functionality, the students may automate the process of producing control code, such that only the STL and pdf drawings are directly provided to MACHINETRON and a successful part is produced.

Each demonstration session will run for 25 minutes, during which students must complete all required setup, install the submachines on the baseplate, carry out tool path computation and loading as required, and activate the GO button. After 25 minutes, the students must cease operations and will have 5 minutes to pack down and clear the testing area, ready for the next team. The time-limits will be rigorously enforced. Build quality may be assessed at any time during the testing slot.

Scoring

Task performance will be assessed by a points system based on demonstrated performance and build quality. Refer to the separate build quality rubric and guidelines for build quality specifications. Only the performance of the overall system will be considered; no part will be considered separately. Systems which do not meet the payload construction and budget requirements will not be eligible for anything but basic functionality and build quality points.

Build Quality	**10/10 Points**

Submachine Basic Functionality x4	**10/10 Points**
Submachine demonstrates motion on each axis and spindle.	2
Activation of the GO button produces movement of the machine	3
Submachine successfully cuts a trajectory	5

Assembled MACHINETRON Functionality	**30/30 Points**
A rough, but recognisable version of the target piece is produced	10
A quality version of the target piece is produced, accurate to <1 mm	15
A precise version of the target piece is produced, accurate to <0.5 mm	5

Advanced Functionality	**20/20 Points**
Each additional copy of the target piece produced	1 per unit
Each additional type of target piece produced	2 per target

Bonus Functionality	**10/10 Points**
Path planning and cutting fully autonomous	5
Cut the Ultimate Shape	5

Apparatus

The provided apparatus consists of the ~~6 mm~~ 12 mm base plate, drilled with 10 mm holes 25 mm apart. Rubber studs will separate the plate from the ground.

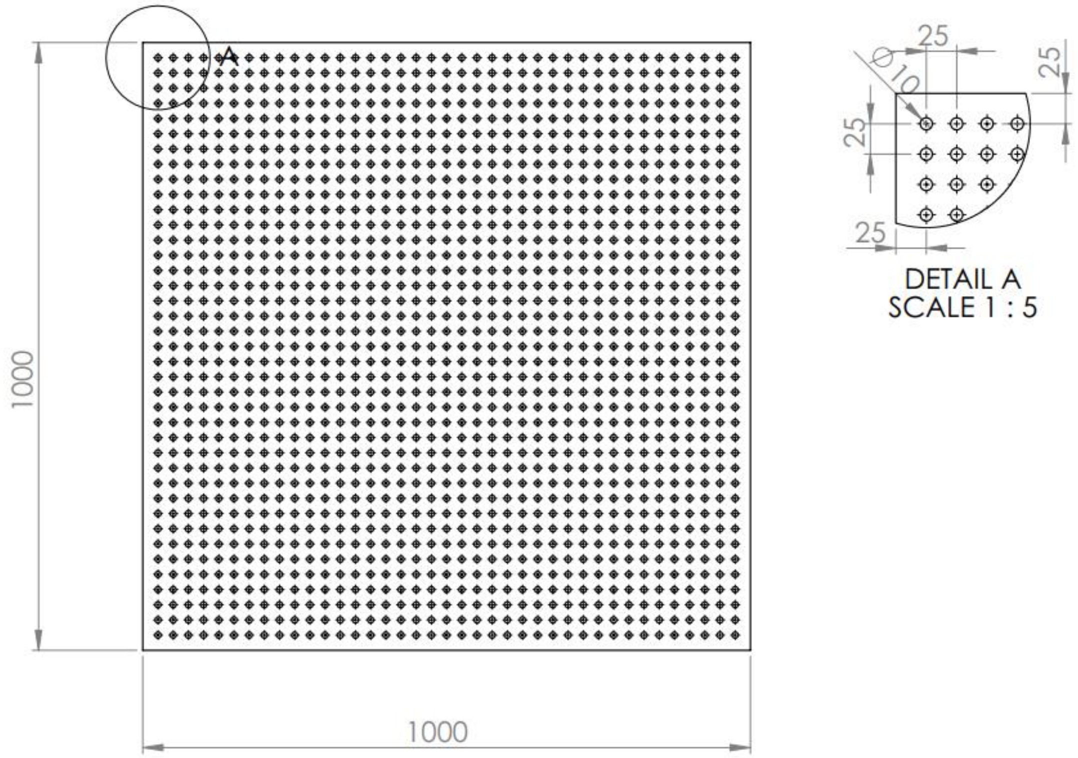

Figure 1: Base plate configuration

System Design Guidelines

Each team must construct a self-contained MACHINETRON system using a limited budget. At least one component must be machined from metal, using milling, turning, water-jet cutting or any combination thereof. At least one custom PCB must be produced. The adjudicator shall be the final arbiter of whether any part of the system, or the system as a whole, is legal within the guidelines. Students may provide their own laptops or desktop computers, which do not count towards size or budget limits.

Modularity and stand-alone testing

The submachines of the MACHINETRON system must be modular, such that each submachine can be removed and validated separately. Each part must be capable of being demonstrated to a basic level with any or all of the other systems missing or non-functional. This may necessitate a stub to stand in for the control functionality of the Handler – eg. a single additional moving axis. During individual validation, other components may be represented by a "boiler plate" – eg. a fixed holding piece to represent the Handler, wired serial input for communications so on. The mechanical and electrical interfaces between each subsystem must be fully specified and documented for submission.

Construction

Dimensions

MACHINETRON's subsystem dimension and mass are limited by the space available on the baseplate to assemble (see Fig. 1), and the need to fit inside a standard box. The entire system, including all support equipment (except laptop/desktop computers), must fit inside a ~~typical~~

~~shoebox~~ BX3 Australia Post mailing box[1] for final submission. The system may be partly deconstructed to fit in the shoebox, with the understanding that students must reconstruct it during the strictly time-limited testing slot for the final demo. Students are strongly advised to design their system with the boxing requirement in mind.

Control

The MACHINETRON system and any subsystems must be autonomous once the GO button is pressed. The team may manually install a work piece, but thereafter may not touch it until the machine comes to a halt. There shall be no physical contact between the operators and MACHINETRON except to set the system in place at the testing position, or remove it. Computer mice and keyboards are considered part of the computer system provision and do not count towards the budget; handheld control interface components such as joysticks, gamepads or space mice are not considered part of the computer, and must be accounted for.

Each submachine must provide a “ready/running/stop” status light. When MACHINETRON is awaiting activation, it shall light up green. When operating, after the GO button has been pressed, the status light must indicate red. Once the sequence has completed, it shall return to green. If, once activated, the GO button is pressed prior to completing the sequence, it shall light up amber indicating a pause, at which point the sequence shall temporarily halt. Pressing the GO button again shall then continue the sequence from the point it was suspended.

Power Sources

Stored energy in MACHINETRON is limited to wall plug power packs, or charged electrical devices and stored elastic energy; no stored gravitational, kinetic, nuclear or thermal energy systems may be used. Exceptions may be granted by the course coordinator on a case-by-case basis. For safety reasons, any proposed elastic energy storage device must be approved by the adjudicator. **Li-poly batteries may total no more than 15 kJ maximum energy capacity.**

Processors and programming

Pre-fabricated processor and computer modules may be used. However, due to abuse by previous students, no Atmega 128/1284/168/2560/324/328/32U4 or ATtiny processors may be used, and Arduino software (IDE, scripts, Wiring platform etc) is strictly prohibited. Exceptions may be granted by the course coordinator on a case-by-case basis (for example, a commercial product that incorporates a 328P processor, but which is non-reprogrammable). It is strongly recommended that teams program using C.

Budget

The total cost of materials, parts and components incorporated in the product shall be no more than ~~$200~~ $400 (excluding laptop/desktop computers). Regardless of actual cost to construct, the team must demonstrate that the product produced *could* be constructed from parts costing less than or equal to ~~$200~~ $400. Up to ~~$200~~ $400 will be provided for purchase orders through ETSG. **Reimbursements will *not* be permitted.**

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[1] This was changed due to abuse of the definition of what constitutes “shoebox” by previous students. Suffice it to say, if you have to redefine commonly understood terms of reference to make your design meet the specification, your work is probably not going to pass muster.

Cost of parts shall be calculated on a per-item basis; parts that are purchased in multiple units may be costed per unit – e.g. a bag of 10 nails for $10 may be charged at $1 per nail used. Bulk unit discounts from suppliers may be applied, provided the quantity of items used in the product is sufficient to earn the discount. Items sourced for free (i.e. not paid for) may be costed at half the market purchase price. Circuit boards must be purchased via ETSG in order to be paid out of budget.

Each team will be provided with 500 g of 3D printer filament in a specified colour. Once this material has been exhausted, no further filament will be provided or nor may be purchased with the build budget. Only the provided filament may be used in submitted work, where permitted. The cost of provided filament does not count towards the budget total.

Specific Prohibitions

- **No metal cutting tools**
  MACHINETRON's cutting tools must be 3D printed from plastic, and may not be made out of metal.
- **No outside components**
  No components, structures, or equipment may be installed outside of the base board. The system may not overhang the base board in any way at start time – once activated, it is permissible for MACHINETRON to move beyond the limits of the base board, but it must remain rigidly attached at all times. No alterations may be made to the Hawken building or apparatus. Systems that cause damage to the apparatus will be prohibited from operating.
- **No internet connection**
  No part of the MACHINETRON may be connected to the Internet. Where WiFi or similar wireless protocols are used to connect between submachine systems or another computer, it must be demonstrated that no computer on its network is connected to the Internet. The instructor may elect to have the connection status of any input device demonstrated prior to testing. The instructor shall be the final arbiter of whether a connection constitutes connection to the Internet.

The Aim of the Project and the Spirit of the Rules

Without a doubt, engineering students are extremely creative and talented at finding clever solutions to difficult problems. This project aims to teach you about the practical trade-offs encountered by engineers when facing a multi-faceted challenge with broad scope and many possible solutions. It is recognised that no set of rules could cover every possible edge-case without becoming cumbersome fodder for 'rules lawyers'.

Thus, the two cardinal rules are:

1. The instructor's decision is final.
2. Stay within the spirit of the problem.

If you think what you are attempting might not be in accordance with the spirit of the rules, there is no harm in asking! The instructor will rule whether a particular approach is permissible. Obviously, it is best to ask these sorts of questions early in the semester and before committing to a particular solution!

Other Miscellanea

By-laws, clarifications and addenda go here. This used to be a short section, but previous years' students have shown that it is *depressingly* necessary to spell-out exactly what you should not be doing. But you're going to be smarter and better dressed than them, *right*? ☺

1. All OH&S inductions and procedures *must* be adhered to. You **WILL** be ejected from the lab if you are unsafe or in violation of footwear requirements. Repeat offenders will be barred from the teaching labs for the remainder of the semester.

2. It is the responsibility of all students to keep the teaching labs in clean, functioning condition. Lab cleanliness will be arbitrated by a warning system, as posted on the class blackboard site and class website. All detritus and debris must be collected and cleared.
    a. The lab status starts at GREEN.
    b. If the condition of the labs deteriorates and becomes messy, status will change to YELLOW, indicating that a clean-up is needed.
    c. If conditions do not improve or deteriorate further, the status will be changed to RED and the labs will be set to fixed-hours, with after-hours access prohibited.
    d. If conditions still do not improve or deteriorate further, the status will be changed to BLACK and the labs will be locked to students until the next practical session, whereupon the labs must be completely cleaned before any non-cleaning work may resume.

3. The following are specifically prohibited inside the lab:
    a. Eating or drinking in the lab (including water), or having food or drink outside of a backpack or bag.
    b. Sleeping in the lab
    c. Leaving the lab door open (all students have access cards)
    d. Giving non-enrolled students/non-students access to the lab
    e. Non-work related activities (e.g. computer games)

    Students found to be violating these rules will have lab access revoked.

4. Under no circumstances may project infrastructure, test equipment, tools, supplies, furniture, etc. be removed from the teaching labs. 'Vegas rules' are in effect: what happens in c404 *stays* in c404. Transgressors will be barred from the teaching labs for the remainder of semester.

5. No grade will be awarded until all assigned tools and equipment are returned and accounted for. Students are separately and collectively responsible for their group's tools.