

**Not In My Backyard
Design Contest
ME72 Engineering Design Laboratory
Fall Term, 1997
Rules and Details**

**Version 1.1, (1:00 pm) October 23, 1997
Final Contest to be held: December 4th, 1997
in: Beckman Auditorium**



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1 Object

The object is to design and build a device which wins a series of contests. In each contest, your device will strive to combine speed, strength, finesse, guile, strategy, etc. to out-perform an opponent device.

The basic contest is for your device to deliver more items from your side of the “arena” over a central ridge to your opponents side, than you opponent delivers from his side to yours. The “contest arena” is a rectangular table approximately 1.25 m wide and 2.5 m long. The table is surrounded by a clear plexiglass border extending 0.3 m above the table top. A triangular ridge, approximately 0.2 m in height, divides the table into two sides. Three views of the “arena” are shown on in Figure 1 on Page 10. Each competitor’s device begins the contest on one (assigned) side of the “arena”, within a set of painted “start-lines”. At the start of the contest, *each side* contains the following items: a) a device situated within a set of painted “starting lines”, b) 3 hockey pucks, c) 3 golf balls, and d) 3 hose washers (upon which the golf balls initially rest). The pucks, balls and washers will be positioned at pre-defined locations prior to the contest, but at the start, and during the contest, these items will not be constrained on the table top in any way. The score at the end of the contest is based on the number and type of items (including devices) on each side of the arena. The side with the lowest score at the end of 35 seconds wins.

⇐ VI.1

- Golf balls are worth 1 point,
- Hockey pucks are worth 2 points,
- Hose washers are worth 3 points, and
- Each device is worth 4 points.

Thus each side starts with 22 points. Your score is based on counting and scoring the items that remain on your side of the ridge at the end of the contest. A device must transfer **at least one** scorable item (other than itself) across the ridge or the round will count as a **loss** for that device.

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Electrical power will be supplied to each contestant's device for 30 seconds. (Two channels of ± 24 volts DC power can be (continuously) modulated separately to each device by use of a two-axis joy stick, there are also two additional independent channels of (switched) ± 12 volts DC.)

2 Evaluation

An overall winner will be chosen in a double-elimination tournament. Double-elimination is just like single-elimination, except a device must lose twice (instead of once) to be eliminated from competition. Pairing of devices to compete will be chosen randomly.

The winner of each contest will be determined at the end of 35 seconds (30 seconds of power followed by 5 seconds without power), by counting and scoring the number of items (golf balls, hockey pucks, hose washers, devices) on each side of the center ridge. The side that has the lowest score wins. Ties are possible, but any device must transfer at least one scorable item (other than itself) across the ridge or the round will count as a loss for that device.

← VI.1

In all cases (particularly those requiring judgement) the judges will decide the winner.

3 Individual Work

It is expected that each device will be designed, and fabricated by one individual.

It is also acknowledged that interaction between students in the class is highly beneficial. To that end, any conversations, calculations, analyses, ideas and tests may be shared among the students, but the device design and fabrication must be an individual effort. Note that this collaboration policy does not extend to replicating others ideas. Occasionally two people will arrive at a very similar solution independently, sometimes one person will see a great idea in someone else's device, and finding no superior alternative will want to incorporate it. This duplication is permissible, however, not encouraged. Competitors usually maintain a high level of secrecy around their device, and blindly copying an idea or strategy may be risky. In many respects, you should treat this design project as similar to an ordinary homework set. It is permissible to collaborate with your classmates and seek the advice of the instructor, TA's, M.E. Shop staff, other class participants, other students, however, the final product must be your own work. If you are concerned about the acceptable limits to collaboration, discuss the situation with the instructor.

Do your own work, and as always, it is best if you use your own ideas and concepts.

4 Important Dates:

Week	Date	Day	Time	Milestone
1	30-Sep	Tue	10:00 am	Zeroth Assignment given.
	2-Oct	Thur	10:00 am	Written Contest Materials distributed.
	2-Oct	Thur	2:00 pm	Pick up "Bag of Junk".
2	7-Oct	Tue	10:00 am	FR's and C's Assignment given.
	9-Oct	Thur	10:00 am	3 Alternatives Assignment given. Mockup Assignment given.
	9-Oct	Thur	2:00 pm	Zeroth Assignment Due .
3	14-Oct	Tue	10:00 am	FR's and C's Due .
	16-Oct	Thur	10:00 am	Design Review (bring Notebook and Mockup).
	16-Oct	Thur	2:00 pm	Design Review (bring Notebook and Mockup). 3 Alternatives Due [5%]. Mockups Due [5%]. Begin building Prototypes of key elements. Begin Fabrication of Device.
4	23-Oct	Thur	2:00 pm	Prototype of 1 key (working) element Due [10%]. Continue Fabrication.
5	30-Oct	Thur	2:00 pm	Continue Fabrication. Begin Testing and De-Bugging.
6	6-Nov	Thur	10:00 am	Design Review (bring Notebook and Device).
	6-Nov	Thur	2:00 pm	Design Review (bring Notebook and Device). Continue Refinement, Testing and De-Bugging.
7	13-Nov	Thur	2:00 pm	First Complete Device Prototype Due [10%]. First version fabrication complete. Continue Refinement.
8	20-Nov	Thur	2:00 pm	Device Function Test [10%]. Size and Weight Test . Continue Refinement.
9	26-Nov	Wed	5:00 pm	Devices Impounded for Thanksgiving Break.
10	1-Dec	Mon	8:00 am	Impounded Devices Returned.
	2-Dec	Tue	10:00 am	Preliminary Contest: Beckman Auditorium. 30 Second Set-up Time Test .
	4-Dec	Thur	10:00 am	Device Size and Weight Test in M.E. Shop Devices Considered Complete. Device Construction to Cease.
	4-Dec	Thur	1:30 pm	Contestants Assemble in Beckman Auditorium.
11	4-Dec	Thur	2:00 pm	Final Contest: Beckman Auditorium.
	9-Dec	Tue	5:00 pm	Contest Evaluations Due .
	11-Dec	Thur		Device Grading. [40%]

5 Details

1. Safety:

- (a) A device which is judged to be a risk of injury to any participant or spectator will be disqualified.
- (b) Any device that causes a scorable item to leave the boundaries of the contest arena will be disqualified.
- (c) It is mandatory that safety glasses be worn at all times while competing and testing. This requirement will be relaxed during the final contest. It is, of course, also mandatory that safety glasses be worn at all times while in the M.E. Shop.

2. Energy Sources:

- (a) The energy used by the device to perform in its contest is limited to the following:

- i. A change in the altitude of the center of gravity of the device.
- ii. Electrical Power supplied by the umbilical cord:

A. 2 channels of $\approx \pm 24$ VDC at ≈ 3.0 amps (max) for 30 seconds. These 2 channels are individually, continuously, controllable by use of a 2 axis joystick. This power can only be converted to useful work by the two (2) large (24 volt, HP) DC electric motor(s) supplied in the “bag of junk”.

B. 2 channels of $\approx \pm 12$ VDC at ≈ 3.0 amps (max) for 30 seconds. The voltage for these channels is controlled by a three position switch (center position: off; with return-to-center springs). This power normally will be converted to useful work by any of the (12 volt) DC electric motors supplied in the “bag of junk”.

Note: Only one motor may be powered by each channel of electrical power.

- iii. Spring Energy stored by deforming any element or elements of your “bag of junk”, including the springs and eight (8) Number 33 Plymouth (brand) pure rubber bands **with the following exception:**

Any **projectile** that is launched can only use spring energy stored by deforming *at most* two (2) of the Number 33 Plymouth (brand) pure rubber bands supplied in the “bag of junk”.

Note: Golf balls, hockey pucks, and hose washers are not considered projectiles.

This rule means that any energy stored in springs that is used to launch one or more projectiles is limited to that which can be stored in two (2) of the rubber bands in the kit. It is permissible to use more spring energy to launch projectiles, so long as by the end of the contest all materials used to launch projectiles (other than the two rubber bands specifically described above) must return to the same stored potential spring energy state that they had at the beginning of the contest.

For example: You may have 8 rubber bands stretched at the start of the contest. Immediately after the start of the contest, all 8 rubber bands are released to launch a projectile. Then, your device must re-stretch 6 of those rubber bands to their originally stretched state by the end of the contest. The same applies to deforming any contest kit materials.

⇐ VI.1

This restriction of two rubber band's worth of spring energy *only* applies to projectile launching. Any element or elements in the kit can be used to store and release spring energy, as desired, for any other function other than projectile launching.

3. Contest Kit Materials:

- (a) The contest devices must be constructed entirely from materials supplied in the "bag of junk". No other materials (either from the shop, or elsewhere) can be used or substituted, with two additions described immediately below:
 - i. In addition to the "bag of junk" a maximum of 113.4 grams [4.0 ounces] (dry cured weight) of RTV silicone casting compound may be used. This casting compound is supplied in bulk. See the Staff in the M.E. Shop if you wish to cast one or more parts out of silicone. The intended purpose of this casting compound is for sealing, however, it may be used for molding tires or tracks or other components.
 - ii. In addition to the "bag of junk" a maximum of 3 meters [118.1 inches] of 2.38 mm [3/32 inch] diameter "Orange-Go" belt material may be used. See the Staff in the M.E. Shop to join the ends of a segment of this material into a continuous belt. The intended purpose of the "Orange-Go" is for power transmission as a belt, however, it may be used as a tire or track material, or for other (non-decorative) purposes.
 - iii. In addition to the contents of the "bag of junk", twenty (20) additional machine screws can be selected from a set of specially marked bins (in the M.E. Shop).
- (b) The black plastic housings of the four (4) ITT/GM door lock actuators are *not* legal parts of the kit and *cannot* be used in your device. The parts inside the housings (motors, gears, etc.) *are* legal parts of the kit and *can* be used in your device.
- (c) Replacement supplies and materials are available on a **limited** basis. If you damage something, or cut it up and then want to do something different with it, see the M.E. Shop staff or one of the TAs. We will do our best to supply replacements, but we cannot guarantee unlimited supplies of all materials. We also cannot guarantee that replacements will be identical to the original.
Remember: Your final device must be able to be fabricated from one complete "bag of junk".
- (d) Glues and epoxies may be used *only* for bonding. Among the prohibited uses of glues is the creation of a composite material using a glue as the matrix.
- (e) Contestants are responsible for providing their own glues and epoxies. Some glues and epoxies will be available in the shop, but to ensure an un-interrupted supply, go to a (hardware) store, and buy your own.
- (f) These materials may be modified in any way (disassembled, cut, machined, ground, etc.).
- (g) The contest materials may not be altered chemically (except locally by glues, for bonding).
- (h) Soldering and brazing are permitted.
- (i) Welding is not permitted.

- (j) The plastic bags included with the materials may be used as part of the device.
- (k) No modifications to the DC electric motors are permitted. Specifically, re-winding of the motors is prohibited, although the toothed-belt pulley on the shaft of the 24 volt motor may be removed. Use great care in removing this pulley to avoid damage to the motor. See the M.E. Shop staff to borrow a tool he has built specifically to remove this pulley.
Note that this toothed belt pulley *is not* a gear, and should *not* be used as one. It will quickly destroy any plastic gear that it meshes with.
- (l) Each DC electric motor must have at least one power lead connected to ground. It is illegal to “bridge” the motors across both power supplies (by connecting one motor lead to one power supply, and the other lead from the same motor to the other power supply). A pin-out of the power umbilical is shown on page 11 of this document.
- (m) Light machine oil, mineral oil, or vegetable oil (depending on the competitor’s preference) can be used **SPARINGLY** to lubricate. Do not contaminate the “contest arena”. Oil contamination of the surface of the “arena” will have a profound influence on the traction of your device, and others. For many traction materials, including tires made of silicone, once they are contaminated with oil it is nearly impossible to effectively clean them.
- (n) Paint or Shellac may be used to insulate the strands of wire, if desired.

4. Contest Device:

(a) **Size:**

- i. When each contest begins, each device must fit into a 20 cm by 40 cm by 20 cm (inside dimensions) [7.874 inches by 7.874 inches by 15.748 inches] plexiglass box.

This rule requires your entire device to actually fit inside a 20 by 20 by 40 cm box at $t=0$, when electrical power is applied, at the start of the contest. This requires that a multi-part or multi-component device must have *all* parts inside a 20 by 20 by 40 cm volume at the start. Note that two 20 by 40 cm boxes will be painted on each side of the contest “arena”. At the start of the contest, your device must be positioned within one of the boxes on the side of the table to which your device has been assigned.

A 20 cm by 40 cm by 20 cm (inside dimensions) plexiglass box is available in the M.E. Shop to test the size of your device.

- ii. While all parts of a modular or multi-part device must be able to be constructed from no more than one (1) kit, only those parts that are competing in any particular competition are required to meet the 20 cm by 40 cm by 20 cm size constraint.

(b) **Mass:**

- i. The upper limit of the device’s mass is 3.50 kg [7.716 lb, 7 lb 11.45 oz]. Devices will be weighed before the contest.

- ii. While all parts of a modular or multi-part device must be able to be constructed from no more than one (1) kit, only those parts that are competing in any particular competition are required to meet the 3.50 kg [7.716 lb, 7 lb 11.45 oz] weight constraint.
- (c) After each device's initial competition (on December 4th), no major design changes will be allowed.
- (d) No manipulation of, or interaction with, a device will be allowed while it is competing, other than by modulating the electrical power supplied to your device by use of your joystick and switch.
- (e) Strategies aimed only at destruction of, or damage to, an opponent device are not in the spirit of the contest, and will not be allowed.
- (f) Make an effort to make your device look good, after all, we want this to be a class act.
- (g) Choose a 2-digit integer number for your device. (Number 00 is reserved for the placebo). Check with the instructor(s) to avoid duplicate numbers. Be sure to display your number prominently on the device.
- (h) *Non-functional* decorations are encouraged.

5. Spatial Rules:

- (a) Each golf ball, hockey puck, hose washer, or device is considered a scorable item. For an item to count as being on one side or the other of the center ridge, it must be *entirely* on one side of the vertical plane defined the center peak.
- (b) To legitimately qualify for victory, the *entire* device must come to rest within the boundaries of the "contest arena", and no part of the device may subsequently leave the "contest arena".
- (c) At the end of the contest, any item that intersects the central vertical plane does not count for any points for either contestant.
- (d) All scorable items, including all parts of each device, must remain within the boundaries of the "contest arena" **before, during, and after the contest.** ⇐ VI.1
- (e) The **boundary** of the "contest arena" is: the planes extending vertically from the *inside* surfaces of the vertical plexiglass walls mounted on the outside edge of the rectangular table, and the *top* surface of the table. This leaves the air above the contest table free range!.
- (f) Each device must be designed to functionally interact with nothing other than: the table top the inside vertical surfaces of the plexiglass sides of the table; the golf balls, hockey pucks, and hose washers; a competing device; and the air.
- (g) Devices may not interact with the outside vertical edges of the "contest arena" in any way, at any time. This means (among other things) that your device may not "hook" over the edge of the table or the plexiglass sides, in any way, at any time. Devices *may* interact with the central peak as it is considered part of the surface of the table.

- (h) Devices may not interact with the bottom (underneath) surface of the table or the table legs.
- (i) Devices **may not** interact with either power umbilical in any way, at any time.
- (j) Devices **may not** interact with the power umbilical support in any way, at any time.
- (k) At the start, before electrical power is applied, each contestant's device must rest entirely within its start box.
- (l) Interaction of your device with your opponent's device (after the start of the contest) is encouraged, however, certain limitations do apply:
 - i. You may not intentionally (or knowingly) damage your opponent's device. Accidental damage is bound to occur. Intentional damage is prohibited.
 - ii. You may not intentionally (or knowingly) eject your opponent's device from the "contest arena" in any way.

6. Contest "Arena":

- (a) There will be no mechanical restraint supplied as part of the start area.
- (b) Intentional damage to the "contest arena" will result in disqualification.
- (c) Intentional damage to the power umbilical will result in disqualification. It is your responsibility to avoid damage to the power umbilical, both during testing, and during the contest. If you have any doubt about the strategy you plan to adopt: See the instructor(s).
- (d) Strategies aimed specifically at interference with, destruction of, or damage to, a power umbilical cord or connector (either your own, or an opponent's) are not in the spirit of the contest, and will not be allowed.
- (e) The structure of the "contest arena" may not be violated (spearing the surface will draw a judge's wrath, and disqualification.)
- (f) The golf balls, hockey pucks, and hose washers will used and shared by all participants, and therefore are considered to be part of the "contest arena", and therefore cannot be permanently altered or damaged in any way at any time.
- (g) A golf ball is 42.8 mm [1.686 inches] in diameter, and has a mass of 45.5 grams [1.60 ounces].
- (h) A hockey puck is 76.2 mm [3 inches] in diameter, 26.2 mm [1.030 inches] thick, and has a mass of 169.3 grams [5.97 ounces].
- (i) A hose washer is 24.1 mm [0.95 inches] in outside diameter, 15.9 mm [0.625 inches] in inside diameter, 3.8 mm [0.15 inches] thick, and has a mass of 1.25 grams [0.044 ounces].
- (j) There are two practice tables. Both will remain in the sub-basement of Spalding Lab (in room 04 Spalding, near the Mechanical Engineering Shop) for the duration of the term. We expect to be able to provide 24 hour access to the contest tables for testing purposes. One will be moved to Beckman Auditorium two days before the contest (by **10:00 am on Tue 2-Dec**); the other will be moved to Beckman Auditorium on the day before contest day. ⇐ VI.1

- (k) If there is sufficient sentiment to do so, and a suitable room can be found, one table may be moved to the SAC for 24 hour testing during the last few weeks of the term.

7. Time:

- (a) During the competition, after a contestant is called to start, a *maximum set-up time of 30 seconds will be allowed*. This rule will be very carefully enforced. Exceeding the 30 second set up time allowed will result in disqualification. To help in this regard, a set up time test will be conducted three weeks prior to the contest. Satisfactory completion of the time test is a *pre-requisite* to competing in the final contest.
- (b) No action of either competing device is permitted prior to the application of electrical power.
- (c) Electrical power will be provided for 30 seconds.
- (d) Any “settling” of the device must occur within 5 seconds after the electrical power is shut off. The winner of each round will be judged at the end of this 5 second settling period.
- (e) A maximum pick-up time of 30 seconds will be allowed for removing *all* of your device after a contest.

8. Miscellaneous:

- (a) A drawing of lots will determine first-round competitors.
- (b) Start side and table assignment (East or West, Left or Right) will be made randomly during the contest.
- (c) During the competition, if you get a *bye*, or your opponent does not show, you will be expected to compete against a placebo. To advance in the competition, your device must legally move at least one item completely over the ridge during the competition against the placebo.
- (d) Be sure to test your device under the most realistic contest conditions possible. Note that there are some unavoidable variations between the two contest “arenas”, both of which will be used during the final contest. If there are conditions that you know will be different during the contest, you may be tuning/debugging your device for non-contest conditions.
- (e) Remember, if you can’t win the contest, losing with style counts.

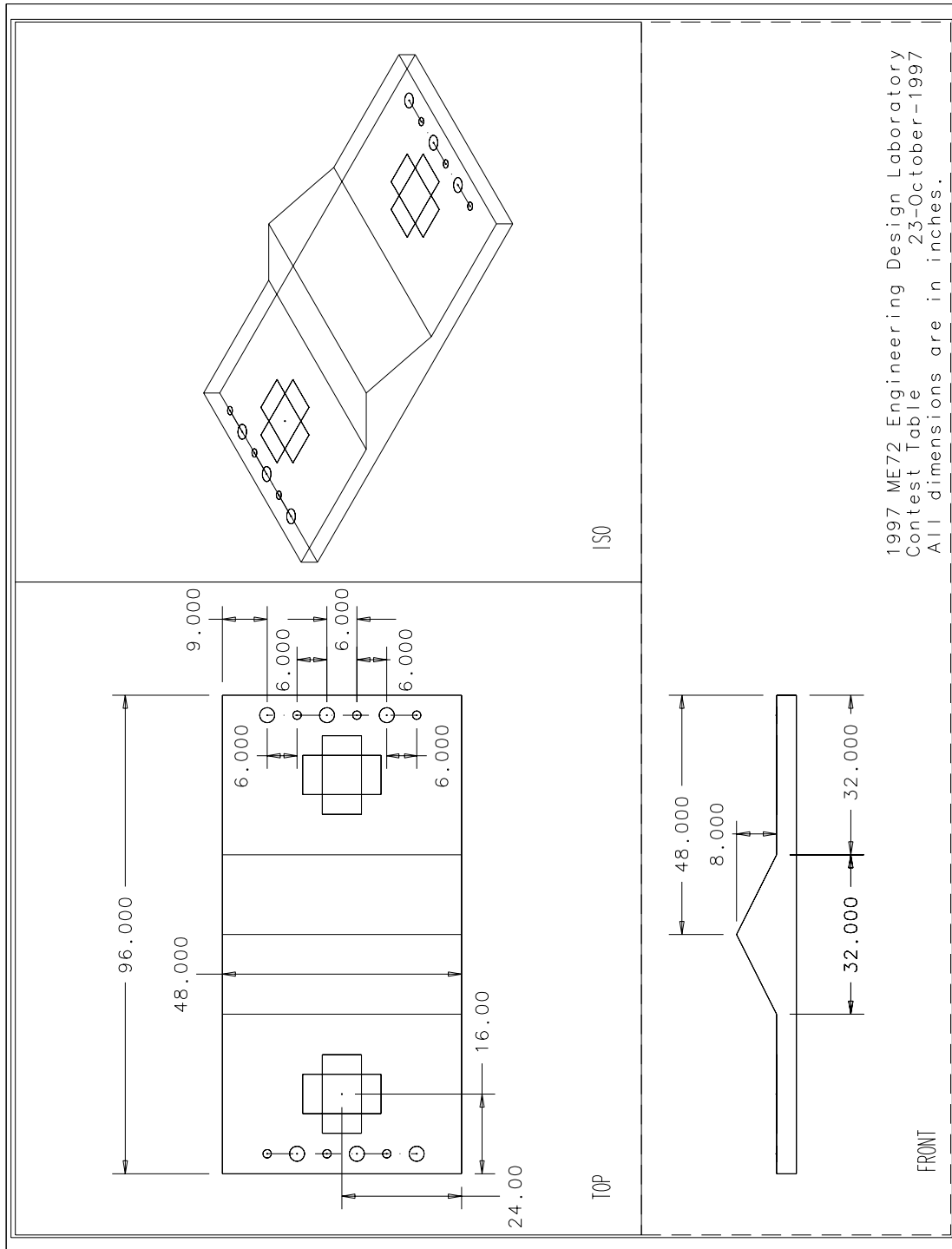


Figure 1: Three Views of the "Contest Arena". Dimensions are in inches.

8 Wire RJ-45 Connector

ORANGE	$\pm 24V$ DC Variable	(Channel A)
BLUE	Channel A Return	
RED	$\pm 24V$ DC Variable	(Channel B)
BLACK	Channel B Return	
GREEN	0 or $\pm 12V$ DC Switched	(Channel C)
YELLOW	Channel C Return	
WHITE	0 or $\pm 12V$ DC Switched	(Channel D)
BROWN	Channel D Return	

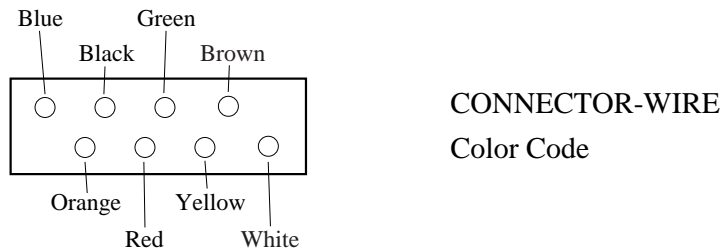
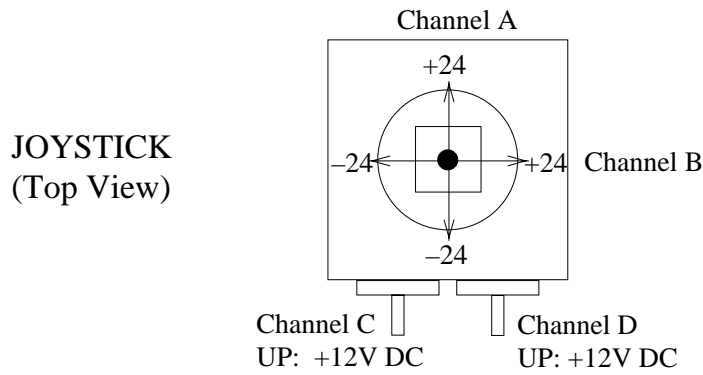


Figure 2: Power Connector Pin-Out.