

Project Design Specifications—Leg Ergometer
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Function: The goal is to design a leg ergometer to be used by William Schrage in his lab. The test subject will use the ergometer to maintain a constant kicking motion while the femoral artery is imaged using an ultrasound. The information is used to determine blood flow to the leg during exercise.

Client Requirements:

- Must be sturdy, last more than a few years
- Adjust for people heights 5'4" to 6'4"
- Maintain a constant wattage throughout testing
- Wattage (0-100) and kick rate (30-60) output to a laptop through an A/D converter
- Flexible range of motion for kicking
- Leg must be able to fully extend when kicking
- Passive return to normal position of the leg after kicking
- Should be set up for right leg testing
- Minimal loose parts

Design Requirements:

1. Physical and Operational Characteristics

- a. *Performance Requirements:* The ergometer should be able to be used at a rate of 30 to 60 kicks per minutes (kpm) and 5 to 100 W of constant power. The kpm and power output should be measured and sent to a laptop through an A/D converter. The kicking leg should have a range of motion of 90 to 180°. The subject should sit in the chair 30° from vertical.
- b. *Safety:* The ergometer should be able to hold an average sized person without putting extreme stress on the components. Also, any elements under tension should be enclosed such that if they come loose, they do not cause harm to any persons near the device. The whole device should be as enclosed as possible so that nothing can get caught in the moving elements. There should be a sufficient amount of enclosed space left in front of the device to allow for full extension of the leg when kicking while ensuring that people in front of the device do not get kicked.
- c. *Accuracy and Reliability:* The device must be able to be set to a single wattage and to run at that setting for at least 20 minutes without deviating. Any data collected from the machine should be consistently accurate.
- d. *Life in Service:* Product should have a lifespan of at least five years.
- e. *Shelf Life:* Device should be stored at room temperature in a clean environment.

- f. *Operating Environment:* The ergometer needs to be durable enough to withstand the test subjects' weight. It also needs to withstand numerous tests with variable force levels and minor transportation.
- g. *Ergonomics:* The device must accommodate test subjects from 5'4" to 6'4" with variable weights. The subject should also sit 3' above the ground at an angle of 30° from vertical. The kicking portion of the ergometer needs a little left-right flexibility to accommodate different test subjects. Overall, the device should be comfortable for the test subjects as well as the researchers to use.
- h. *Size:* The ergometer needs to be approximately 5' long by 3' wide by 3-4' tall. It should be easily portable (with wheels).
- i. *Weight:* The product should contain a comfortable chair for the patient. Also a part which measures the force from the patient is needed. In order to include those parts, the product will be at least few hundred pounds. The ergometer will be placed in a room in a research facility; it is not necessary to move this machine often.
- j. *Materials:* If a belt is included in the design, materials other than nylon should be used, since the heat changes the length of the belt. Also, we need to use durable materials, and a comfortable seat for the patient.
- k. *Aesthetics, Appearance, and Finish:* The previous design was somewhat crude looking. The new design should be streamlined and compact, with as few extra parts as possible.

2. Production Characteristics

- a. *Quantity:* The client only requires one unit at this time, although there is the possibility of additional units used in the future.
- b. *Target Production Cost:* The budget for this project is \$2,000.

3. Miscellaneous

- a. *Standards and Specifications:* Local and national safety standards must be met.
- b. *Customer:* Should have a platform for person holding the ultrasound to rest their arm so that it stays steady. Also the ergometer should be adaptable for use with the left leg in addition to the right leg.
- c. *Patient-related concerns:* The ergometer should provide relative comfort to the user while maintaining stabilization of the thigh while kicking.
- d. *Competition:* Ergometers are available in many different styles including ellipticals and stationary bicycles. There are examples of ergometers similar to this proposed design in use in several research facilities. One example of this type of ergometer was used in a research study published in the following article: P. Andersen and B. Saltin, Maximal perfusion of skeletal muscle in man. J Physiol..