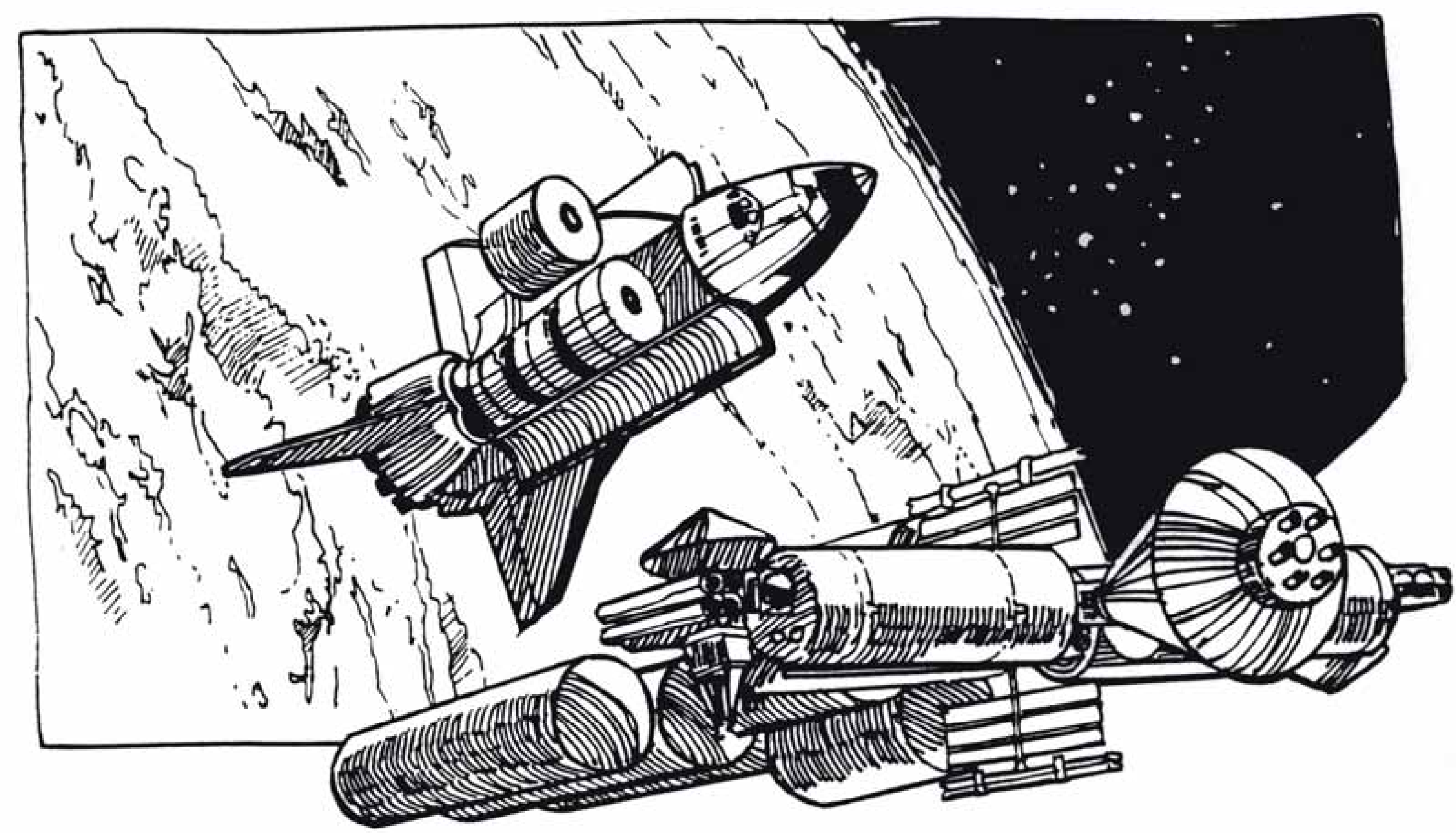


Human Energy and Space Fitness

Introduction

When students are asked to mention energy sources, they normally note gasoline, the sun, the sea, coal, and others. Rarely will students mention the energy contained in food. They also do not think about the energy a human consumes and expends while working or exercising. To maintain fitness a human must expend energy. On earth this is easy to accomplish, in space it is more difficult and requires that engineers design equipment to enable humans to maintain their fitness during extended space voyages. The primary part of this activity is to have junior engineers in high school design and fabricate a model of an exercise machine for use in space.

In addition, since work both consumes and produces energy there may be ways to capture the products of expended human work energy, i.e., water (from sweating) and carbon dioxide (from heavier breathing). Methods of doing this are currently very inefficient, but maybe the junior engineers in your class will be the future engineers who research and design such methods

A New Challenge

One of the most exciting challenges humans face in the next thirty years is to learn to live and work in space. Life aboard space stations and spacecraft traveling between Earth and the moon and Mars may become routine for literally hundreds of people. One of the great debates among spacecraft designers is whether these spacecraft should recreate some or all of the Earth’s gravitational environment, or should not rotate and let the inhabitants remain in a weightless environment. All spacecraft flown so far have required the astronauts or cosmonauts to adapt to the absence of gravity. Unfortunately, when the human body does not have to use the energy necessary to fight gravity-to pump blood from the feet back to the heart, to stand up, to walk, to run, to lift objects-the muscles in the body atrophy -become much weaker. Also, bones lose some of their calcium, and there are other changes in body chemistry.

The early Mercury, Gemini, and Apollo spacecraft were so small that exercise to combat the effects of what is called the "microgravity" environment was almost impossible. On the larger Skylab space station, an area as big as a three-bedroom house, there was plenty of room for exercise The astronauts had a bicycle ergometer (exercycle), which measured how much energy they used during exercises, and could do gymnastics and other exercises in the large forward compartment.

Cosmonauts from the former Soviet Union aboard their Mir space station wear garments that force muscle activity to try to maintain conditioning. Space Shuttle astronauts can tie themselves with bungee cords to a treadmill and walk for fitness. The expending of energy in exercise will not halt all of the effects of microgravity, but research so far has shown that it helps, and that without it, returning astronauts could have serious problems readjusting to gravity here on Earth.

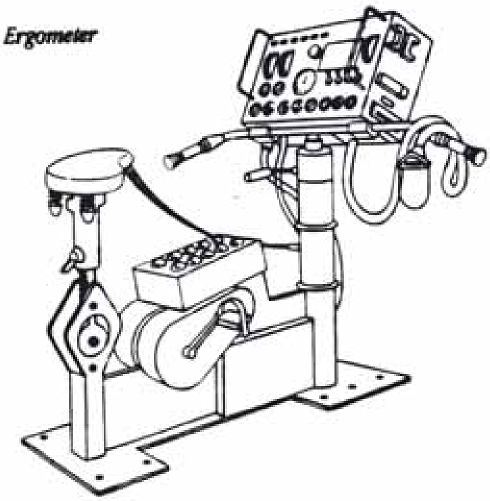
Grade Level

High School

Objectives

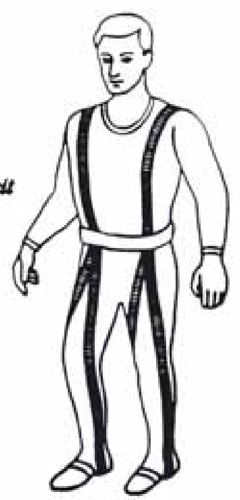
Students will design a working model of an exercise machine that can be used in space. They will discover basic elements of ergonomic design relative to human musculature and will learn how different designs can consume different amounts of energy.

Ergometer



Treadmill

"Penguin" Suit



Materials

Some materials that could be used for a small demonstration model might include:

- Rubber bands
- Springs
- Paper cups
- Wood dowels
- String
- Cloth
- Pulleys
- Paper and pencils
- Elastic cord
- Bicycle tire tubing
- Metal washers
- Pulleys (eyelet screws)

The visiting engineer should be prepared to bring sufficient quantities of all these materials to the class with him/her. Students will be working in small teams. Be sure to have enough materials to engage five teams of about five people each.

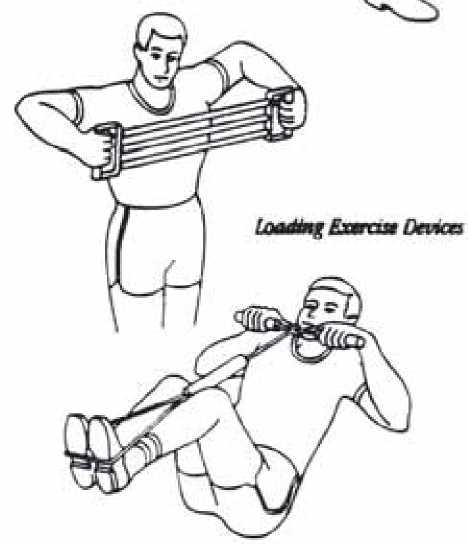
If you elect to use hooks, screws, or other potentially destructive item, please check with the teacher first to be sure there are suitable mounting points in the classroom.

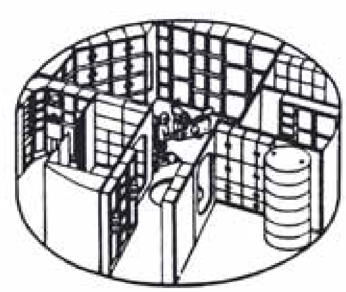
If you have a source of different diameters and lengths of elastic cord (shock cord or bungee cord) or segments of inner tubes, it is possible to design full-size working models of exercise equipment (simple exercise equipment using elastic cords is currently on the market, but the student's designs may be more inventive).

Since exercise devices generally involve puffing or pushing against objects with resistance or mass, a space exercise device, or the exercising astronaut, would have to be anchored. Students may use their desks, the slats on the back of chairs, doorknobs wall hooks, or other fasteners to anchor their model, the full-size exercise devices, or themselves.

Procedure

(The project assumes a 50-minute period to complete all parts, but this activity can be accomplished in 35 -40 minutes by being





very efficient and reducing some of the individual time allocations):

1. Begin by asking students what are sources of energy. List these on the board. It's likely they will not mention food or work-generated energy. (5 minutes)

2. Provide a brief presentation (3 minutes) related to the introductory comments noted above. This will provide a context for the activity to follow.

3. Form students into teams of about five students each. You can explain that engineers often work in teams because each person brings new ideas to the design process. You should also mention that the purpose of engineering is to design new, better, and more cost-effective products. Scientists discover new knowledge; engineers use knowledge to develop products that improve the quality of life. (3 minutes)

4. The students now have 10 minutes to design the next-generation exercise device for space travelers. The criteria for the design follows:

A. The design should be original to the group or individual.
B. The design should be a model or full-size depending on the materials provided. If the design is a model, it should demonstrate the basic working principles of a full-size implementation.
C. The model should demonstrate the types of exercise the astronauts would do and compare them to similar exercises on Earth.

5. Each team should demonstrate its model to the class. This will take approximately 2 minutes for each team.

6. Conclude with a discussion of such things as:

A. Which product, in full size, would be most compact?

1. B. Which product, in full size, exercises the greatest number of muscular groups?
2. C. Which product, in full size, will produce the greatest workout in the shortest time?

7. You may conclude your presentation at this point by describing the types of engineers who may work on such a project. There is a role on this design team for engineers from many disciplines. (5 minutes)

Extended Activities

(These activities can be conducted by the teacher in future classes, or the teacher may ask you to return to continue the experiments.):

1. Have the students research how many calories are burned in different activities (running, walking, weight training, cycling, etc.). Then have them estimate the energy in calories required by their devices.

Questions

A. Which would bum the most calories?
B. Which would provide the best aerobic workout for the heart muscles?
C. Which would provide the best overall workout for the most muscles?

2. Since exercise produces water (sweat) this increases the humidity in the spacecrafts cabin atmosphere. This humidity can be captured as water, which can be used for hygiene and recycled on long-duration missions. Have the students suggest a design for capturing the humidity and recycling it.

3. Have the students research how many calories of food intake they need per day. Space physicians would like adult astronauts to have up to 3000 calories of food and beverage per day. How many hours of exercise using their devices would be needed to bum 1000 calories?

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Sponsor

This activity was developed by the Total Learning Research Institute in cooperation with the Junior Engineering Technical Society.

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