Chess From Trash

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Design, prototype, and demonstrate a chess game (board and pieces) made from recyclable materials used to assemble a surface habitat on the Moon, or Mars.

The Marshall Space Flight Center (MSFC) is developing a prototype surface habitat, and this project is intended to demonstrate methods of recycling/repurposing material that would other wise end up as trash.

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Problem: NASA is going to the Moon and Mars. Along with all the supplies for food, batteries, equipment, experiments, sample containers, and tools, there will be a lot of packing material that will potentially become trash–food containers (cans, plastic wrap, plastic pouches), packing foam, Cargo Transfer Bags (no cardboard boxes), and tape. Lots of supplies will be sent there. NASA will try hard to have dual use packaging and send as little waste material as possible to keep the trash down, but some trash is inevitable.

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Can anything be made out of this trash so that it becomes something valuable for the astronauts? As a demonstration of what is possible, HUNCH Design and Prototype would like to demonstrate how trash materials could be turned into something valuable and useful.

Table 4. Types of Waste Resources.

	Textiles	Polymers	Metallics	Organics	Foams	Other
Potential Resources	• Cotton/cellulose • Polyester • Nomex	• PE • PP • Nylon • Nitrile • PTFE	• Aluminum • Titanium • Stainless Steel • Copper	• Food Waste • Fecal • Urine Solids	• Zotek F30 • Plastazote LD45R	• Undefined materials • EVA • Composites • Mixed Metallics

This is a pretty limited list of materials because NASA is concerned with flammability. Choosing low flammability means choosing materials with high melting temperatures and low chemical reactivity. Instead of thermal plastics (melt to reform the shape), they may choose Thermal Set plastics (2 part chemical compounds to make the plastic–doesn't melt easily). This makes these materials difficult to recycle. Part of what your project is going to suggest is that NASA needs to choose more recyclable materials if that is what is needed on the moon and Mars.

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There are two options for making the chess game:

Solution #1

Chess board and pieces made from **recyclable materials without the use of 3D printer.** The dimensions are the same as the 3D printed game. The board must measure 12 inches by 12 inches, and chess pieces scaled accordingly (style is important–be unique). You may use any recyclable material, and construction methods but they have to come from trash.

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Solution #2

3D printed chess board and pieces. The board must measure 12 inches by 12 inches, and chess pieces scaled accordingly (style is important–be unique). The first printers sent to the Moon will have small print platforms so you must limit your print area to 6 inches by 6 inches. Due to the limit on print area the board will need to have interlocking joints to assemble the board. Your print material must be a recycled plastic ~~(not purchased)~~ can be purchased. You must use at least two colors for each chess set such as traditional black and white, or blue and red, or something else--you choose.

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Your final prototype must be durable and easy to clean. You will need to document testing that it can withstand drops from a height of 3 feet and is water resistant.

Make your pieces creative and unique! Don't just copy and replicate what other chess pieces look like.

Be aware of the types of packing material NASA uses. Glass is frangible and cannot be launched into space. Food items are typically packaged in plastic pouches.

Your prototype must not off-gas.

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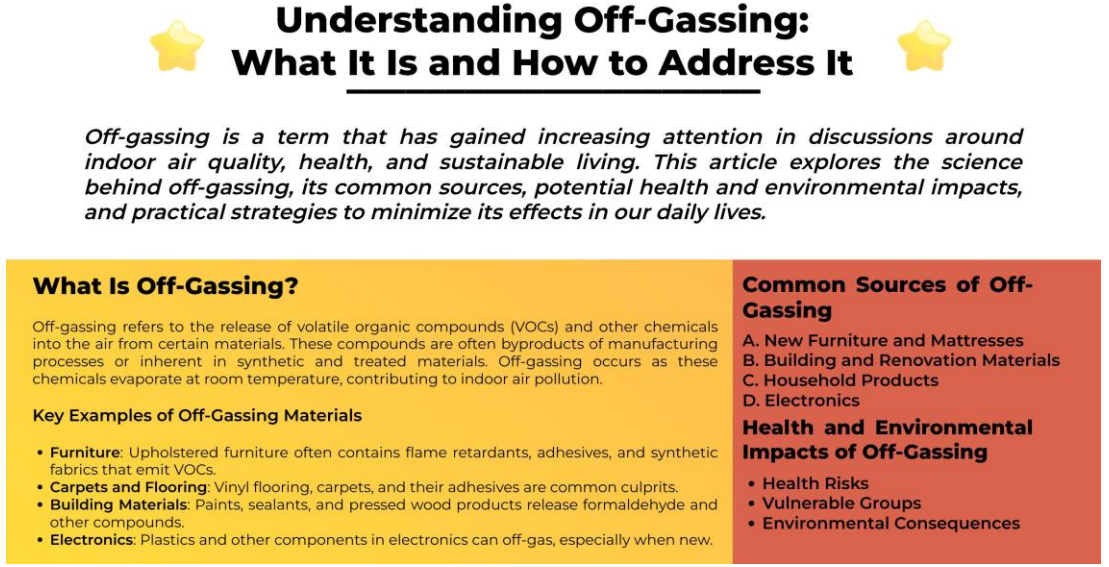
For NASA, "off-gassing" or "outgassing" refers to the release of gases from materials, particularly within the confined environment of spacecraft. These gases can include volatile organic compounds (VOCs) and other substances that can contaminate the spacecraft atmosphere, potentially affecting crew health and the functionality of sensitive equipment. NASA rigorously tests materials for off-gassing to ensure a safe and reliable environment for space missions.



Understanding Off-Gassing: What It Is and How to Address It

Off-gassing is a term that has gained increasing attention in discussions around indoor air quality, health, and sustainable living. This article explores the science behind off-gassing, its common sources, potential health and environmental impacts, and practical strategies to minimize its effects in our daily lives.

What Is Off-Gassing?

Off-gassing refers to the release of volatile organic compounds (VOCs) and other chemicals into the air from certain materials. These compounds are often byproducts of manufacturing processes or inherent in synthetic and treated materials. Off-gassing occurs as these chemicals evaporate at room temperature, contributing to indoor air pollution.

Key Examples of Off-Gassing Materials

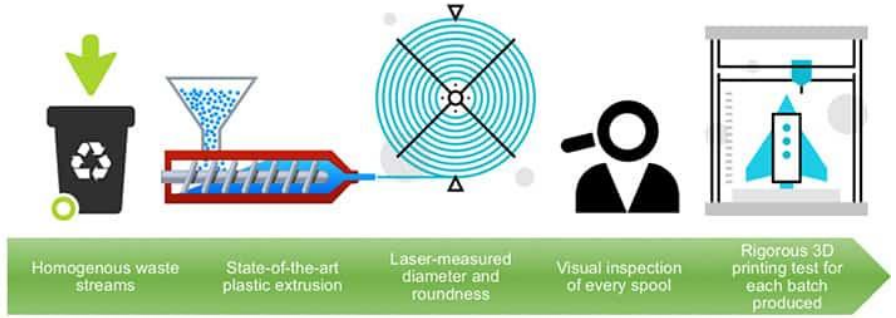
- **Furniture**: Upholstered furniture often contains flame retardants, adhesives, and synthetic fabrics that emit VOCs.
- **Carpets and Flooring**: Vinyl flooring, carpets, and their adhesives are common culprits.
- **Building Materials**: Paints, sealants, and pressed wood products release formaldehyde and other compounds.
- **Electronics**: Plastics and other components in electronics can off-gas, especially when new.

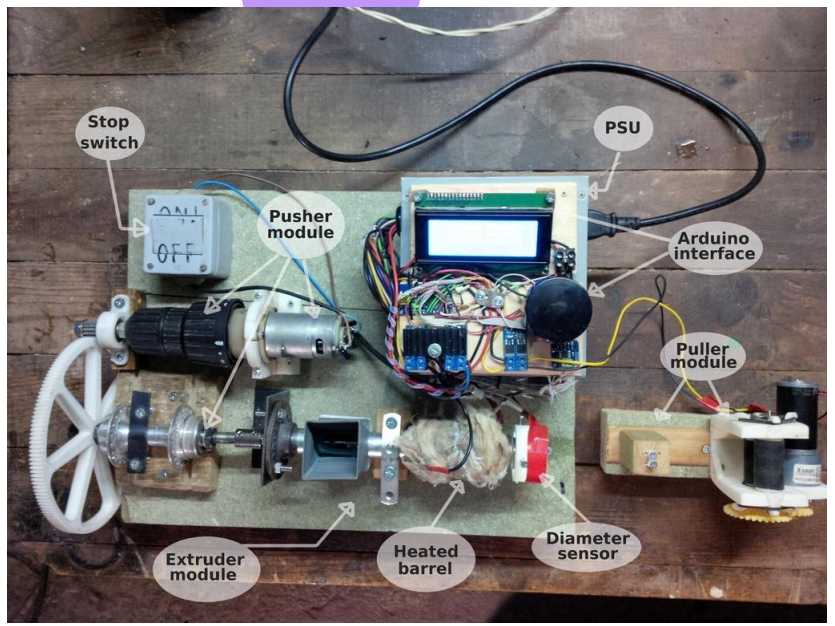
Common Sources of Off-Gassing

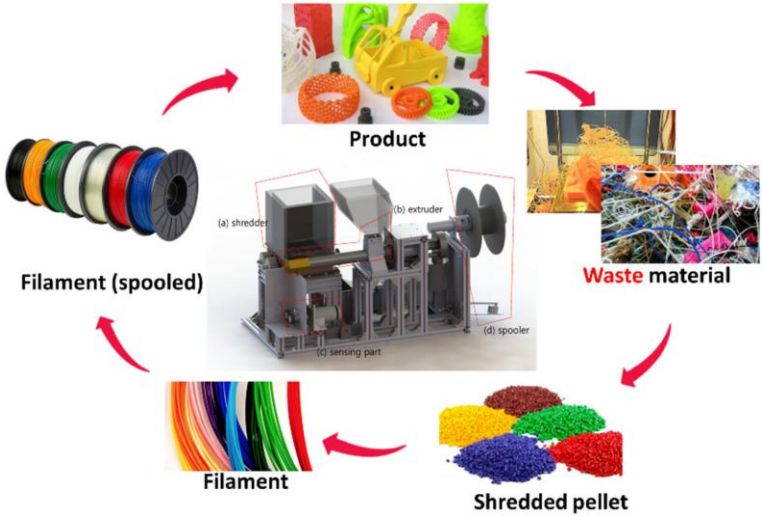
A. New Furniture and Mattresses
B. Building and Renovation Materials
C. Household Products
D. Electronics

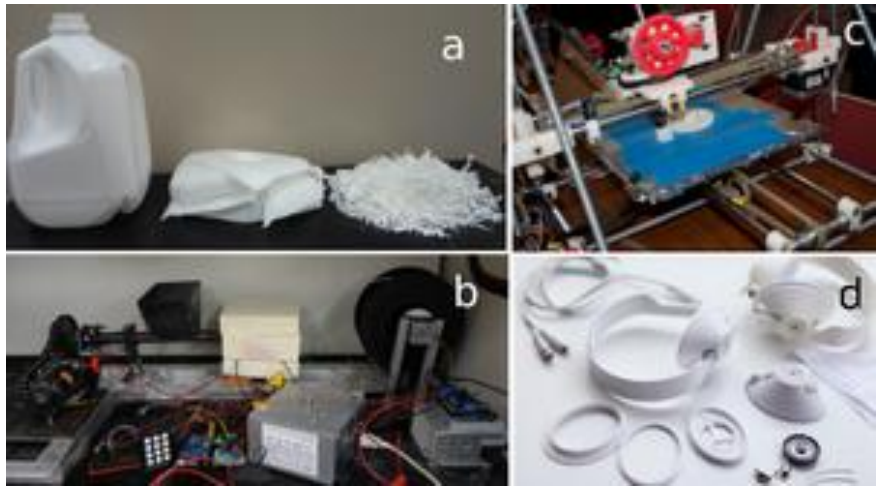
Health and Environmental Impacts of Off-Gassing

- Health Risks
- Vulnerable Groups
- Environmental Consequences









PETG Recycle Filament

Recycle bottles, Recycle 3D print waste, use recycled 3D filament

Anything 3D printed should be printed with a recycled filament–either your team recycled the plastic into filament or you purchased recycled filament. Are there any quality differences with recycled filament?

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Your final prototype should demonstrate the ability to recycle/reuse materials to minimize waste. You may also choose to mix options and construct some pieces from 3D printed RECYCLED plastic and others from recycled trash.

The Moons gravity is 1/6th that of Earth's. It will be challenging to keep the pieces stable on the board if people bump into it. The pieces must either snap into / lock onto the board or be weighted to maintain stability. Come up with something besides magnets (unlikely to be available as trash). Velcro is also over used and is responsible for a portion of the dust on the ISS because some particles come off each time the pieces are pulled apart.

Student Questions

Wondering if there would be a place to access a stl file to 3-d print any of the caps or parts from some of the food containers NASA uses? My student might try to incorporate them into the pieces. If not can we just model something that looks close and print them to represent the caps or pieces from the food packaging?

I don't have any STLs for food containers but here is a link that can help.

https://www.nasa.gov/ochmo/food-in-space/

"Space Food Packaging" will probably be the most helpful of the articles. It seems like the clear packaging you see in this will be the most likely material to be recyclable since it doesn't have an aluminum layer. Check out the video lower on the page. It gives a lot of great information about food in space and about the packaging.

NASA chooses to send up materials that have a low flammability but that means some of them are not easy to recycle. Plastazote, Zotek, Minicel, and Pyrell are used for NASA packing. Plastazote can be recycled but Zotek is unlikely since it is a thermoset plastic. Teflon is commonly used for space applications but not recyclable and polycarbonate is used but is difficult to recycle. NASA does use ziplock bags–a good option.

If NASA is serious about controlling its trash on the moon by recycling packaging materials, they will need to choose materials that are easier to recycle. This is part of the project. Help NASA choose/find materials that have low flammability but are easier to recycle.

- Will small springs and ball bearings be available as waste materials to use in the construction of our pieces?
  - Small springs and ball bearings are ok. where do you think you would get them from?
- Will our prototypes need to be made of recycled plastic, or can we use commercial filament (if we plan on using a 3d printer)?
- If we need to use recycled plastic, are we able to purchase it online or must we process it ourselves?
  - Prototypes should be made of recycled plastic. It would be nice if you are able to produce the recycled plastic yourself.
  - Do a google search for recycling plastic into filament.

Comments from PDRs and discussions with students

- The largest the board can be is 12in x 12in but you can be creative with the height of the board
- You can make the board smaller if you like.
- Your board must have at least 2 colors but you can have more colors if you like
- After a player captures a piece, where do you put it? If it gets bumped it could be lost with 1/6th Earth gravity.

Requirements for Chess from Trash

There are three options for making the chess game:

Solution #1 Chess board and pieces made from recyclable materials without the use of 3D printer. The dimensions are the same as the 3D printed game. The board must not exceed 12 in x 12 in, and chess pieces scaled accordingly (style is important so be unique). You may use any recyclable material and construction method, but they must come from trash.

Solution #2 3D printed chess board and pieces. The board must not exceed 12 inches by 12 inches, and chess pieces scaled accordingly (style is important so be unique). The first printers sent to the Moon will have small print platforms so you must limit your print area to 6 inches by 6 inches.

Solution #3 combination of the previous 2–some parts 3D printed, some parts made of trash materials

1. All materials must be from recycled materials. 3D printed materials should be printed out of recycled filament when possible.
2. Board must not exceed 12in x 12in, but can be smaller. Thickness is determined by the team.
3. No piece of the board or playing pieces can be printed larger than 6in x 6in (trash pieces can be any size)
4. Some kind of storage for pieces for during play or between games (either on, in, around or adjacent to the board)
5. Chess pieces will be of an original design instead of simple traditional shapes or from an internet web design (no Thingiverse or similar 3D print library)
6. Demonstrate that the pieces will stay with the board if bumped hard
7. Board and playing pieces will be made of at least 2 colors
8. Set must be cleanable.