IMMC 2021 Greater China Problem C (Winter) (English 简体 繁體)

Construction of Lunar Station

Background

On November 24, 2020, China launched Chang'e 5 lunar probe which returned to Earth on December 17 after successful lunar landing and sampling. It has been more than 40 years since last time humankind brought back to Earth lunar rock and soil samples. This move has further stimulated the interest of mankind in the scientific exploration of the Moon. Those aerospace powers have scheduled manned lunar landing plans in their agenda in which establishing the Moon base is a key task in order to carry out long-term and large-scale scientific research on the Moon.

Scenario Setting

The Chang'e series of lunar probes conducted a comprehensive survey of the lunar surface, selected an area on the Moon with a flat landform, and analyzed thoroughly composition of the lunar regolith in this area. The scientific research has verified that it is possible to use 3D printing methods for construction of space with such lunar regolith in the above-mentioned area. It is planned for humankind to deliver excavators and 3D printing machinery suitable for the lunar working environment to the Moon before 2035 and build a lunar work station by remotely controlling such machinery.

The basic idea of the lunar station is to use 3D printing to construct a building on the lunar ground with the excavated lunar regolith on the surface of the Moon as the raw material. The building on the ground and the underground space by the excavation will then form a closed shelter space similar to an aerospace station that can accommodate 20 astronauts to work and live (so far no need to consider the interior layout of the space, the way of entering and exiting, ventilation and other issues).

Tasks

Your team is invited to design the geometric shape of the closed shelter space (including both the foundation excavation part and the building part on ground) on the Moon, which is spacious enough for the lunar station. Based on the modeling analysis, your team needs to reduce the amount of excavation as much as possible while meeting the space requirement, and with all of the excavated materials being used for 3D printing to shorten the construction period and reduce construction costs. At the same time, in your team's design (such as the wall thickness of the building), you need to take into account of the drastic changes in the temperature of the lunar surface so that the interior temperature of the closed space formed is suitable for human living, and the completed structure must conform to the basic principles in your subjects of physics and mechanics.

Submission

Your solution paper should include a one-page Summary Sheet. The body cannot exceed 20 pages for a maximum of 21 pages with the Summary Sheet. The appendix should include a design drawing or demonstration of the lunar space station, and the design drawing or demonstration is not included in the limit of 21 pages (if the drawing or demonstration is submitted in multimedia format, the total compressed file submitted cannot exceed 17M).

References

1. 3D printing

   - Goulas, A., Binner, Jon G.P., Harries, Russell A. and Friel, J. (2017), Assessing extraterrestrial regolith material simulatnts for in-situ resources utilization based 3D printing, Applied Materials Today, 6:54-61. https://doi.org/10.1016/j.apmt.2016.11.004

   - A short viedo about 3D concrete printing, https://www.youtube.com/watch?v=MK5vvZfbWNo

2. Thermal conductivity

   Thermal conductivity on Wikipedia
   https://en.wikipedia.org/wiki/Thermal_conductivity

IMMC 2021 中华赛 C 题（冬季赛） （English 简体 繁体）

建造月球工作站

背景

2020 年 11 月 24 日，中国发射了「嫦娥」五号探月器，在月球登陆成功采样后，于 12 月 17 日返回地球。此次探月距上一次人类将月球岩石和土壤样本带回地球已相隔 40 余年。此举进一步激发了人类对月球进行科学探索的兴趣，诸多航天大国将载人登月计划纳入日程，并将建立月球基地作为重点任务，为在月球进行长时间、大规模的科学研究创造条件。

情景设定

嫦娥系列探月器对月球表面进行了综合探测，选定了具有平坦地貌的月球地表区域，并对该区域的地表物质成分进行了详尽分析。科学研究已验证了可以将上述地区的地表物质作为原材料，利用 3D 打印的方式建造房屋。人类拟于 2035 年前，向月球运送适合月球工作环境的挖掘机以及 3D 打印机械，通过在地球上遥控上述机械的方式，建造月球基地。

建造月球科研工作站的基本思路是：将挖掘出来的月球地表物质利用 3D 打印的方式，在地表上建造房屋，该房屋和挖掘形成的地下空间构成一个类似太空站、可容纳 20 个宇航员工作和居住的封闭掩体（暂无需考虑空间内部的布置、掩体出入方式、通风等其它问题）。

任务

你的团队受邀设计月球上地基开挖和建造房屋的几何形状，以形成足够月球工作站使用的闭合空间。你的团队需基于建模分析，在满足空间使用要求的情况下，尽可能减少开挖量，并将开挖的材料全部用于 3D 打印，以缩短施工工期，减少建造成本。同时，你团队在设计方案中（如房屋壁厚）需考虑月球表面环境温度的剧烈变化，使形成的闭合空间内部温度满足人类生活需求，建成结构需符合你所学的物理和力学基本原理。

提交

你的团队提交的论文应包含 1 页“总结摘要”，其正文不可超过 20 页（总页数限于 21 页以内）。论文的附录和参考文献应置于正文之后，不计入 21 页之限。附录需包括月球工作站的设计示意图或演示，设计示意图或演示亦不计入 21 页之限（如以多媒体形式提交示意图或演示，则提交的总压缩文件不可超过 17M）。

参考文献

1. 3D 打印

   - Goulas, A., Binner, Jon G.P., Harries, Russell A. and Friel, J. (2017), Assessing extraterrestrial regolith material simulatnts for in-situ resources utilization based 3D printing, Applied Materials Today, 6:54-61. https://doi.org/10.1016/j.apmt.2016.11.004

   - 一条 3D 混凝土打印的短片 https://www.youtube.com/watch?v=MK5vvZfbWNo

2. 热传导
   https://en.wikipedia.org/wiki/Thermal_conductivity

建造月球工作站

背景

2020 年 11 月 24 日，中國發射了「嫦娥」五號探月器，在月球登陸成功采樣後，於 12 月 17 日返回地球。此次探月距上一次人類將月球巖石和土壤樣本帶回地球已相隔 40 余年。此舉進一步激發了人類對月球進行科學探索的興趣，諸多航天大國將載人登月計劃納入日程，並將建立月球基地作為重點任務，為在月球進行長時間、大規模的科學研究創造條件。

情景設定

嫦娥系列探月器對月球表面進行了綜合探測，選定了具有平坦地貌的月球地表區域，並對該區域的地表物質成分進行了詳盡分析。科學研究已驗證了可以將上述地區的地表物質作為原材料，利用 3D 打印的方式建造房屋。人類擬於 2035 年前，向月球運送適合月球工作環境的挖掘機以及 3D 打印機械，通過在地球上遙控上述機械的方式，建造月球基地。

建造月球科研工作站的基本思路是：將挖掘出來的月球地表物質利用 3D 打印的方式，在地表上建造房屋，該房屋和挖掘形成的地下空間構成一個類似太空站、可容納 20 個宇航員工作和居住的封閉掩體（暫無需考慮空間內部的布置、掩體出入方式、通風等其它問題）。

任務

你的團隊受邀設計月球上地基開挖和建造房屋的幾何形狀，以形成足夠月球工作站使用的閉合空間。你的團隊需基於建模分析，在滿足空間使用要求的情況下，盡可能減少開挖量，並將開挖的材料全部用於 3D 打印，以縮短施工工期，減少建造成本。同時，你團隊在設計方案中（如房屋壁厚）需考慮月球表面環境溫度的劇烈變化，使形成的閉合空間內部溫度滿足人類生活需求，建成結構需符合你所學的物理力學基本原理。

提交

你的團隊提交的論文應包含 1 頁“總結摘要”，其正文不可超過 20 頁（總頁數限於 21 頁以內）。論文的附錄和參考文獻應置於正文之後，不計入 21 頁之限。附錄需包括月球空間站的設計示意圖或演示，設計示意圖或演示亦不計入 21 頁之限（如以多媒體形式提交示意圖或演示，則提交的總壓縮文件不可超過 17M）。

參考文獻

1. 3D 打印

   - Goulas, A., Binner, Jon G.P., Harries, Russell A. and Friel, J. (2017), Assessing extraterrestrial regolith material simulatnts for in-situ resources utilization based 3D printing, Applied Materials Today, 6:54-61. https://doi.org/10.1016/j.apmt.2016.11.004

   - 一条 3D 混凝土打印的短片 https://www.youtube.com/watch?v=MK5vvZfbWNo

2. 熱傳遞
   https://en.wikipedia.org/wiki/Thermal_conductivity