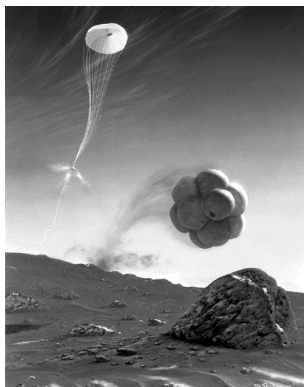




Laboratory 4: Landing on Mars

Experiments are to be completed on the provided laboratory sheets ONLY; any supporting material (eg. graphs) should be attached. Make sure you and your partner(s) name(s) are clearly indicated on the front page of your lab. **Neatness & clarity count!** Use complete sentences in answering questions, explain your answers clearly & fully, and *write down any equations* before using them in a calculation (i.e. before you insert numbers & solve). **Show all of your work!**

Labs must be written using *non-erasable media* and are due a week after the lab.

**** Do NOT include intro or theory pages in your file submissions for marking. ****

APPARATUS

Scissors, rulers, triple-beam balance, cardboard, soda straws, duct tape, scotch tape, rubber bands, string, tissue/newspaper/bubble wrap/balloons/etc, raw egg.

OBJECTIVES

1. To consider and evaluate important criteria for a successful “soft” landing
2. To design, build and test packaging incorporating these criteria

THEORY

When landing on the Moon or Mars, significant hurdles (including intense vibrations, temperature and pressure variations, and successful transfer of the lander’s *kinetic energy* to its surroundings) must be overcome to ensure the payload survives. Early solutions used rocket engines and

parachutes to slow landers before reaching the surface. However, rockets require fuel, which is expensive and heavy, reducing scientific payload; parachutes require an atmosphere thick enough for significant drag. As a result, *passive* systems (similar to an automobile's airbags or crumple zones) were developed to absorb and redistribute the energies of impact, protecting the payload.

Such systems are ultimately dependent on the *impact velocity*, and as such must take into account relevant variables such as *drag* (air resistance - shape and size) and *fall height* (to the limit of terminal velocity on bodies with atmospheres). Mass will not play a role in impact velocity if a body is airless, but in an atmosphere it affects the value of terminal velocity for an object. In addition, mass will be an important part of the *momentum* and the *kinetic energy* of an object, both of which must become zero after impacting the surface.

Mark this lab: ☐ individually
☐ as a group

NAME:
PARTNER:

Laboratory 4: Landing on Mars

Part A: Design & Approval

1. Form teams of three (3). **Elect a team manager** to coordinate & represent your group.
2. Your team manager will randomly draw your available lander resources. **Circle your category:**

A	B	C	D
Any available materials	As in “C” plus balloons (4) and duct tape (1ft)	As in “D”, plus straws (4) and double newspaper	String (1m), rubber bands (4), scotch tape, newspaper (2 sheets), cardboard (1 ft ²)

3. Design and construct a lander (within restrictions above) to allow an egg placed within to survive a 10.0 m fall onto a solid surface (eg. a random throw from the roof to the concrete road below). **NOTE:** check the size & mass of your lander **before** final assembly! **Lander construction must be complete *before the end of the lab* for testing by the NASA Project Director.**
4. [2 marks] *How* (if at all) do mass, size, shape and fall height affect the lander impact?

Part B: Design, Construction and Testing

1. Mass & size are critical in that it is expensive to boost large, heavy payloads into Earth orbit (or beyond). **As such, your entire landing package must remain *below* a total mass of 200g, *including the egg*, and must be *less than 25 cm in any dimension*. You may *not* directly tape or cover your egg and you **MUST** be able to *reasonably easily* insert & remove the egg, *i.e.* your lander must include some sort of ‘door’ or hatch.**

2. Submit a rough design to NASA Project Director Dr. G. Arkos for approval ***BEFORE*** building.

3. [2 marks] Lander mass (*incl.* egg): _____ g Lander max dimension: _____ cm

Lander name/cool NASA acronym: _____

4. [2 marks] The Project Director will test your lander by tossing it (*in a random orientation*) off the roof onto the concrete below. **Circle your lander’s resulting EAI in the table below.**

Egg Assessment Index (EAI)			
1	2	3	4
shell intact	shell cracked	shell broken	shell broken
yolk intact	yolk intact	yolk intact	yolk broken

Note: EAI=1 (2 marks); EAI=2 (1 mark); EAI=3 (0.5 mark); EAI=4 (0 marks).

5. [2 marks] Which of *your* lander design element(s) worked *best*? Discuss.

6. [2 marks] Discuss *two* changes to improve *your* design, regardless of your EAI.

7. [*5 marks*] Make a detailed, **FULLY** labelled drawing of your design & materials **below**. Include several different views to clearly illustrate your design/construction.



8. [5 marks] Explain the rationale for ALL aspects of your design *FULLY*.



NOTE: half of the marks for this lab are for drawing/rationale, so document your ideas **in detail**.