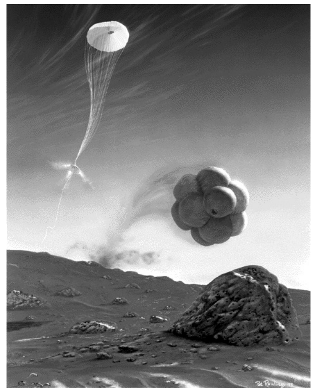

Laboratory 4: Landing on Mars

Experiments are to be completed on the provided laboratory sheets below; any supporting material (eg. graphs) should be attached. Make sure your name and your partners name(s) are clearly indicated on the front page of your lab. **Neatness and clarity count!** Use complete sentences in answering all questions, explain your answers when asked clearly, and if you use an equation to do a calculation, *write the equation down* first, then put in numbers and solve. **Show all your work!**

Labs must be written *in pen* and are due a week after the lab.

APPARATUS

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

OBJECTIVE

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.

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 yolk intact	shell cracked yolk intact	shell broken yolk intact	shell broken 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**.