Space for Telescopes

Space Week 2021

Primary Classroom Resource Booklet

Telescope Background Information

Telescopes can be made in a wide variety of ways. The very first telescope was designed from two lenses over 400 years ago. In 1609 Galileo made a *refractor* telescope of his own and used it to look at the Moon.

Isaac Newton designed a different type of telescope in 1668. Newton's *reflector* used mirrors, but at that time it was too hard to make a good mirror, so most telescopes continued to be made with lenses until the early 1700s.

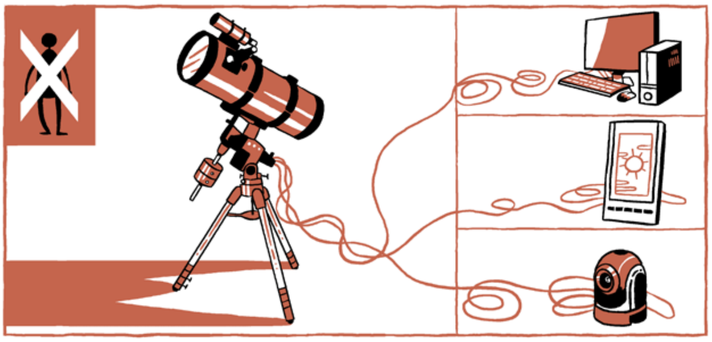
Optical telescopes use visible light, but other telescopes are designed to collect radio waves, infra-red light, ultraviolet light or even X-rays. Different wavelength telescopes can look very different to typical reflectors or refractors.

Some telescopes are robots and they can work without direct human control.

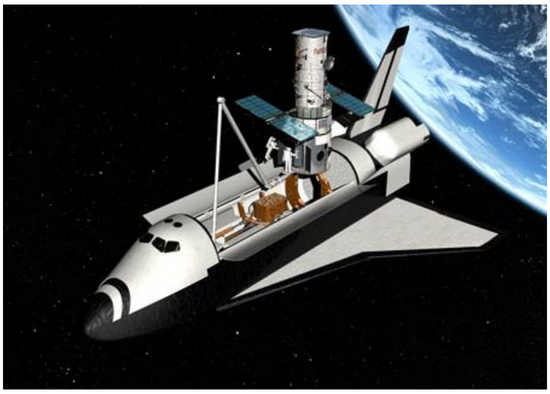
The Earth's atmosphere can affect the light that a telescope can collect, so many telescopes are built on mountains, where the atmosphere is thinner. Even so, there are limits, so some telescopes have been designed to work in space. The most well-known of these is the Hubble Space Telescope, but there are many more. See [ESA's Fleet Across the Spectrum]

I-LOFAR aerial view, credit Alison Delaney, Birr

Optical telescopes at Blackrock Castle Observatory



Robotic telescopes



Hubble Space Telescope

This resource booklet was originally produced for Engineers Week 2021.

Acknowledgements: The Folding James Webb Space Telescope Model has been adapted from the Deployment Demonstration Model by Dave Dooling of the New Mexico Museum of Space History, which was, in turn, derived from a model by John Jogerst.

Mirror Mathematics was adapted with permission from the ESERO UK James Webb Space Telescope Activities.

DPSM/ESERO Framework for Inquiry

Theme	Space for Telescopes
Curriculum	**Strands:** Materials, Energy & Forces, **Strand Units:** Properties and Characteristics of Materials, Light, Curriculum Objectives: …describe and compare materials/investigate how materials can be used in construction/identify how materials can be used. Light: how mirrors and other shiny surfaces are good reflectors of light **Skills Development**: Observing, questioning, predicting, measuring, investigating and analysing. Maths: Shape, 2D Shapes – tessellate combinations of 2-D shapes.

Engage

Considerations for inclusion

The Trigger	Wondering	Exploring
Images of small refractors, reflectors, Hubble Space Telescope, Arecibo radio dish, I-LOFAR and James Webb Space Telescope	What is a telescope? What types of telescopes are there? Where would you put a telescope to get the best view of the Universe? Why is the James Webb Primary Mirror made of hexagons? (The mirror has been designed so that tiles that are the same distance away from the centre can be made in the same way. Hexagons have the fewest number of different distances – children can explore this in Mirror Mathematics.)	Which is bigger? The Hubble Space Telescope or the James Webb Telescope? See https://youtu.be/j3mk6tUokm4 Children can compare the similarities and difference between the two telescope primary mirrors. Older children (5th / 6th class) and teachers can explore telescopes with https://jwst.nasa.gov/content/features/educational/scopeItOut/game/index.html Make a model James Webb Space Telescope. (see video at https://youtu.be/eYRuvyfAAoI)

Investigate: ESERO 15 Take a Look (for Junior Classes)

Starter Question	Predicting	Conducting the Investigation	Sharing: Interpreting the data / results
Will the children be able to see more or different things when they look at the leaves and minibeasts through a magnifying glass? What kind of things?	Children should predict what they think will be different when looking through a magnifying glass. They might reference the close-up picture of the flower.	Children should draw what they see with and without the magnifying glass.	Ask the children what they have drawn. Did the leaves and the minibeasts look different through a magnifying glass? What was different? Was this what they expected?

Investigate: Mirror Mathematics

Starter Question	Predicting	Conducting the Investigation	Sharing: Interpreting the data / results
What tessellating shape makes the best mirror?	Children should identify shapes that tessellate. Squares and hexagons should be used, older students might explore triangles. (The tiles that are the same distance from the centre of the mirror can be constructed the same way. The best design will have the fewest different type of tiles.)	Make a tessellating tile pattern that covers the mirror surface. Measure the distance to the centre of each tile from the centre of the mirror design. Colour tiles that are at the same distance the same colour.	Which tessellating shape is the best? What lines of symmetry can the children see? What would happen if another row of tiles was added around the outside?

Investigate: Test a Space Telescope

Starter Question	Predicting	Conducting the Investigation	Sharing: Interpreting the data / results
Will our telescope survive a shake test?	Children could compare each other's models and predict (with reasons) which ones will be most robust. Children might refer to the materials used.	Children should plan how the models can undergo the same type and duration of shake testing. Fold the models and place inside a 2-litre soft drink bottle. Children should decide how to record the effects of the shake test on their models. They might use photographs of before and after.	Children should present their results in a way that allows for comparison.

Take the Next Step

Applying Learning	Making Connections	Thoughtful Actions

What hexagon-based art might the children make? Art inspired by the James Webb Telescope can be seen here: https://www.jwst.nasa.gov/content/features/jwstArt/

Children could use procedural writing to describe how the James Webb Space Telescope folds and make a flip book animation using their model.

Children might investigate the back plane of the James Webb Primary Mirror. How has it been designed to be lightweight, yet strong? Design a Bridge could be adapted as Bend a Mirror, using tissue paper for the mirror and paper straws taped to the back as supports.

Reflection	
	Did I meet my learning objectives? Are the children moving on with their science skills? Ask the children if they enjoyed the lesson. What questions worked very well? What questions didn't work well? Ask the children would they change anything or do anything differently. Are there cross curriculum opportunities here?

15

Take a look!
Looking at the universe

time
65 minutes.

learning outcomes
To:
- know that you can use a magnifying glass to see an object in more detail
- learn to use a magnifying glass to look at a leaf and a minibeast
- draw and describe observations
- know that a drop of water and a circular glass of water have a magnifying effect
- know that a telescope makes things look much bigger so you can see the stars more clearly

materials needed
- photographs of a flower (Appendix)
- class set of
  - plastic containers and small paintbrushes
  - plastic magnifying sheets/ magnifying glasses
  - sheets of paper with small text
- elastic bands
- minibeasts
- leaves from trees
- cling film
- circular glass filled with water

Preparation

For the activity **Large and small** you will need the photographs of the flower from the Appendix.
Make sure that you have the materials needed for Zooming in on nature ready to take with you. For the activity **Water as magnifying glass** prepare sheets of paper with small text.

Large and small 5 min.

Sit in a circle with the children. Show them the close-up photograph of the flower. Encourage them to describe what they can see on the photo. What do they think it is? Then show them the photograph of the whole flower. Do the photographs look the same? Explain that the first photograph is a magnified detail of the first photograph. Can the children point to the part of the second photograph that shows the detail they can see in the first one? What can they see on the first photograph that they can't see on the second one?
Ask the children what you can use to magnify something. Explain that you can use a magnifying glass. Glasses are also a sort of magnifying glass. Ask the children why it is handy to have a magnifying glass or glasses. Explain that you can take something very small and make it look big, so you can see it better.

The children examine leaves and minibeasts, with and without a magnifying glass.

Ask a few children whether they think they will be able to see more or different things when they look at the leaves and minibeasts through a magnifying glass. What kind of things?

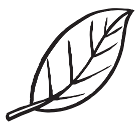
Zooming in on nature 50 min.

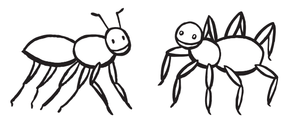
Take the children outdoors, providing each with a plastic container. Explain that half the children are to collect leaves and the other half minibeasts; they are to place them gently inside their containers. Help the children to catch the minibeasts using the small paintbrush to transfer them to the container. Emphasise that they must be gentle with the minibeasts. Seal the containers with cling film, making sure there is enough fresh air for the minibeasts. Fasten the cling film with an elastic band. When all the children have a leaf or a minibeast in their container, return to the classroom.
Encourage the children to draw on the worksheet what they see with and without using a magnifying glass. Ask them to swap jars so that everyone has the chance to draw a minibeast as well as a leaf on their worksheet.
At the end of the lesson take the children outside to set the minibeast free.

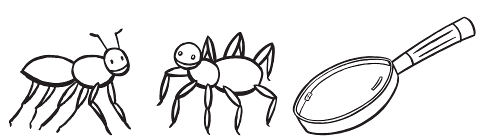
Ask the children what they have drawn. Did the leaves and the minibeasts look different through a magnifying glass? What was different? Was this what they expected? Ask why a magnifying glass can be useful. Explain that a magnifying glass helps you to see things better. A magnifying glass that helps you to see things a long way away is called a telescope. A telescope is very good for looking at the stars, which are also a long way away. You can find stars all over the universe. The universe is the big space all around the Earth. A telescope lets you see things in the universe that you can't see just using your eyes.

Water as a magnifying glass 10 min.

Give each of the children a sheet of paper with small text and place a drop of water over a letter. Can they see the letter better now? Hold the paper with small text behind a glass of water. What can the children see? Is the text easier to see? Come to the conclusion that a drop of water and a glass of water both act as a magnifying glass.







Flower [close-up and view from above] • **LESSON 15**

Mirror Mathematics

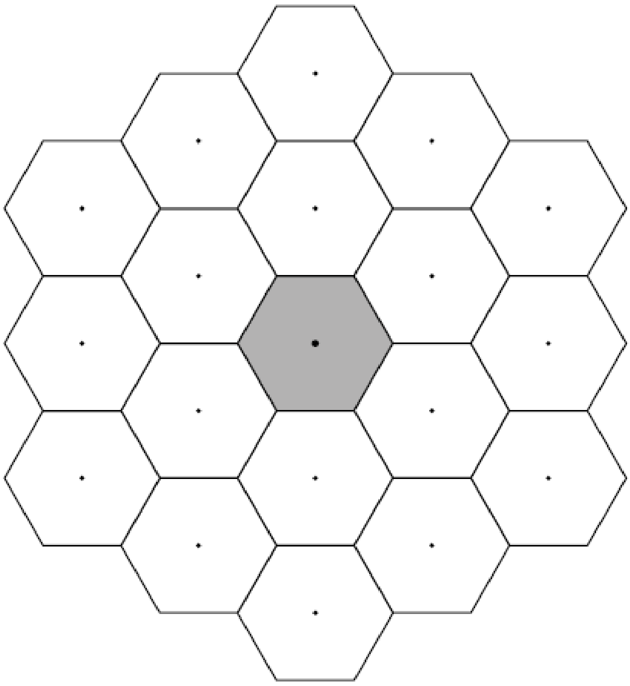
(adapted from ESERO UK James Webb Space Telescope Teaching Activities)

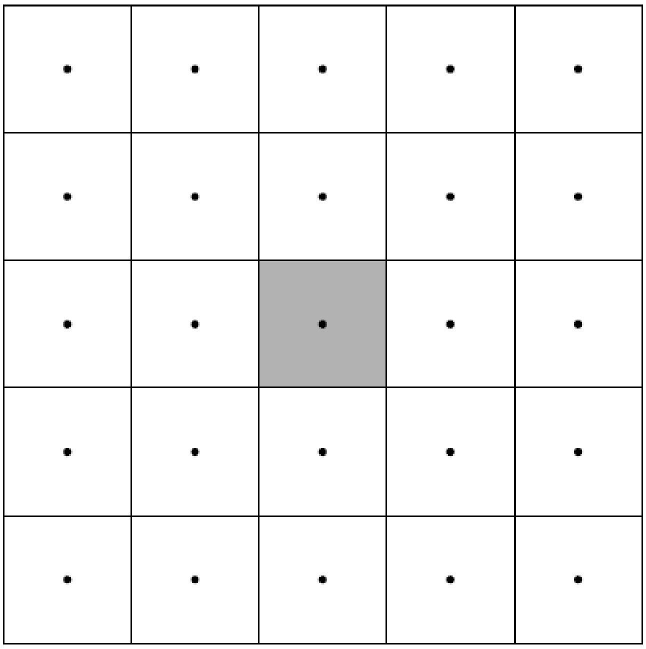
The James Webb Space Telescope has a mirror made of separate tiles.

Tiles at the same distance from the centre can be thought of as the same type of mirror. The best design will have the fewest different types of mirrors.

Two possible shapes that tessellate are shown.

Measure the distance between each tile and the tile at the centre. Tiles that are the same distance from the centre should be coloured in with the same colour.





Which mirror pattern has the fewest different colours? That mirror pattern will be easier to make.

Can you explain in your own words why the James Webb Space Telescope was designed with hexagons and not squares?

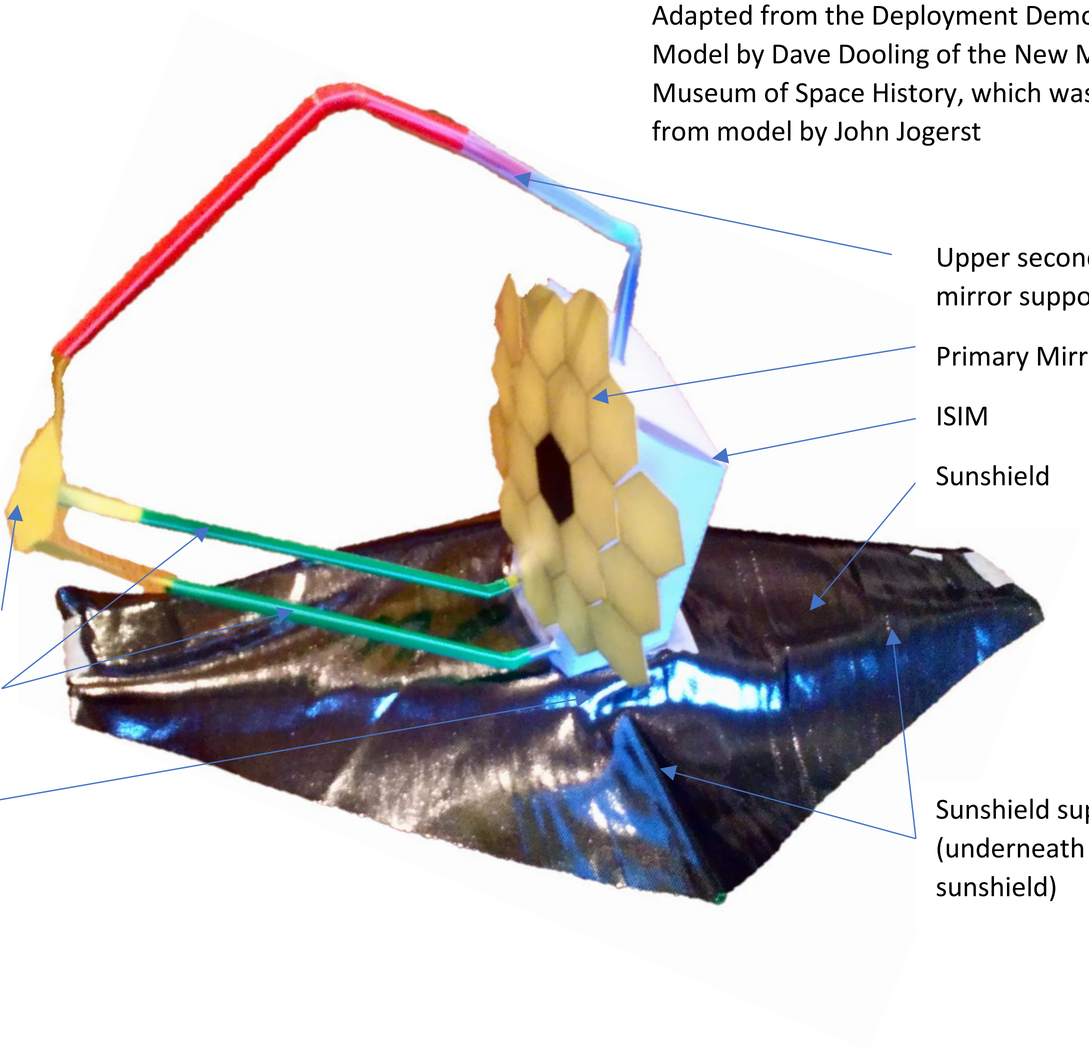
Further explorations:

Are there other shape(s) that could tessellate to cover the mirror? They can be drawn and then explored in the same way.

If you were to fold these mirrors (so that they would fit in the Ariane 5 payload), which mirror tiles would you fold? The actual mirror is roughly 6.5 m wide, and the Ariane 5 is only roughly 4.6 m wide.

Folding James Webb Space Telescope Model

Adapted from the Deployment Demonstration Model by Dave Dooling of the New Mexico Museum of Space History, which was derived from model by John Jogerst



Components and Finished Dimensions:
Sunshield 39 cm by 25 cm

Sunshield supports: total length 38 cm by 4 cm wide, made from flexible straws, 8 needed. Off cuts can be used for the side sunshield supports.

Secondary mirror support structure: made of flexible straws, 7 needed (4 for the two lower secondary mirror supports, 3 for the upper secondary mirror support)

Integrated Science Instrument Module (ISIM): 4 cm by 5 cm by 9.5 cm rising to 13 cm

Primary mirror: 14 cm by 13 cm, to be mounted on the ISIM

Secondary mirror: 3 cm hexagon with 5 cm support struts

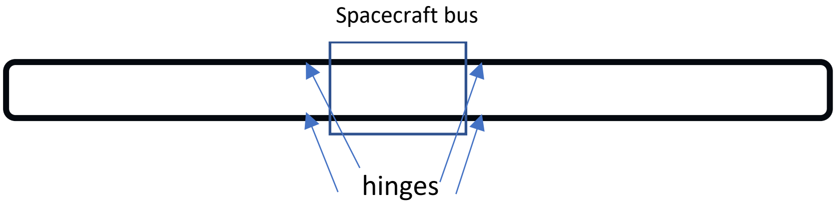
Spacecraft bus: 5 cm by 5 cm by 3 cm

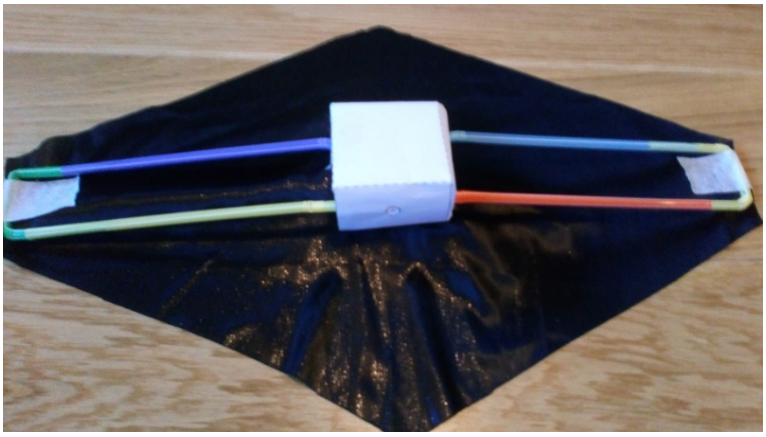
How to assemble:

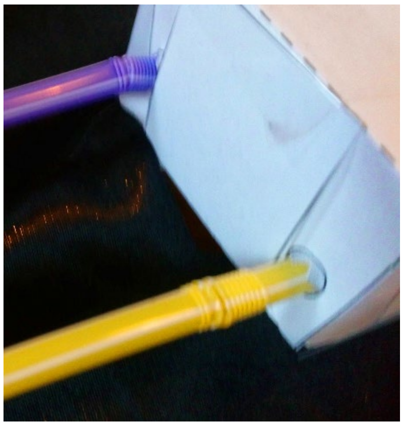
1. Print **spacecraft bus**, **ISIM** and **mirrors** on card. Use scissors to cut out and a hole punch to make holes as indicated. Cut on solid lines, fold on dashed lines. Glue tabs to make the rectangular **spacecraft bus** and the irregular **ISIM**. Cut out the **primary** and **secondary mirrors**. Attach the sides of the **primary mirror** with the cardboard hinges.

2. Print **sunshield** template on paper. Fold silver survival blanket material (or other reflective silver material) in half, place the **sunshield** template on the fold line and cut out.
3. Use flexible straws to make the **support structures**. Snip or fold one end of a straw to insert it into another straw.

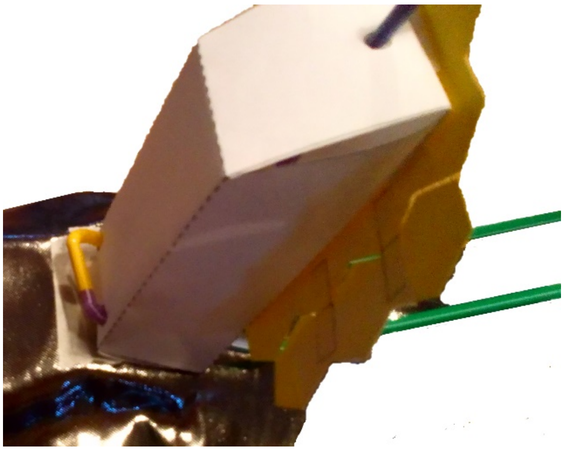
   a) **Sunshield support** is a large, rounded rectangle with U-shape ends, total length 38 cm. Flexible sections make the hinges next to the **spacecraft bus**.







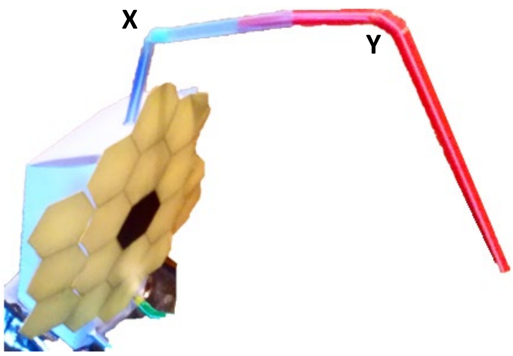
Assemble the ends of the **sunshield support** by cutting down two straws and connecting them into a U-shape. Repeat for the other end of the support. Connect two straws at their flexible end and push through the **spacecraft bus**, then attach to the U-shape ends. Repeat to complete the **sunshield support structure**. Attach the **spacecraft bus** to the underside of the **sunshield** and tape the **sunshield** to the U-shape ends of the **sunshield support structure.**



b) **Secondary mirror support structure**

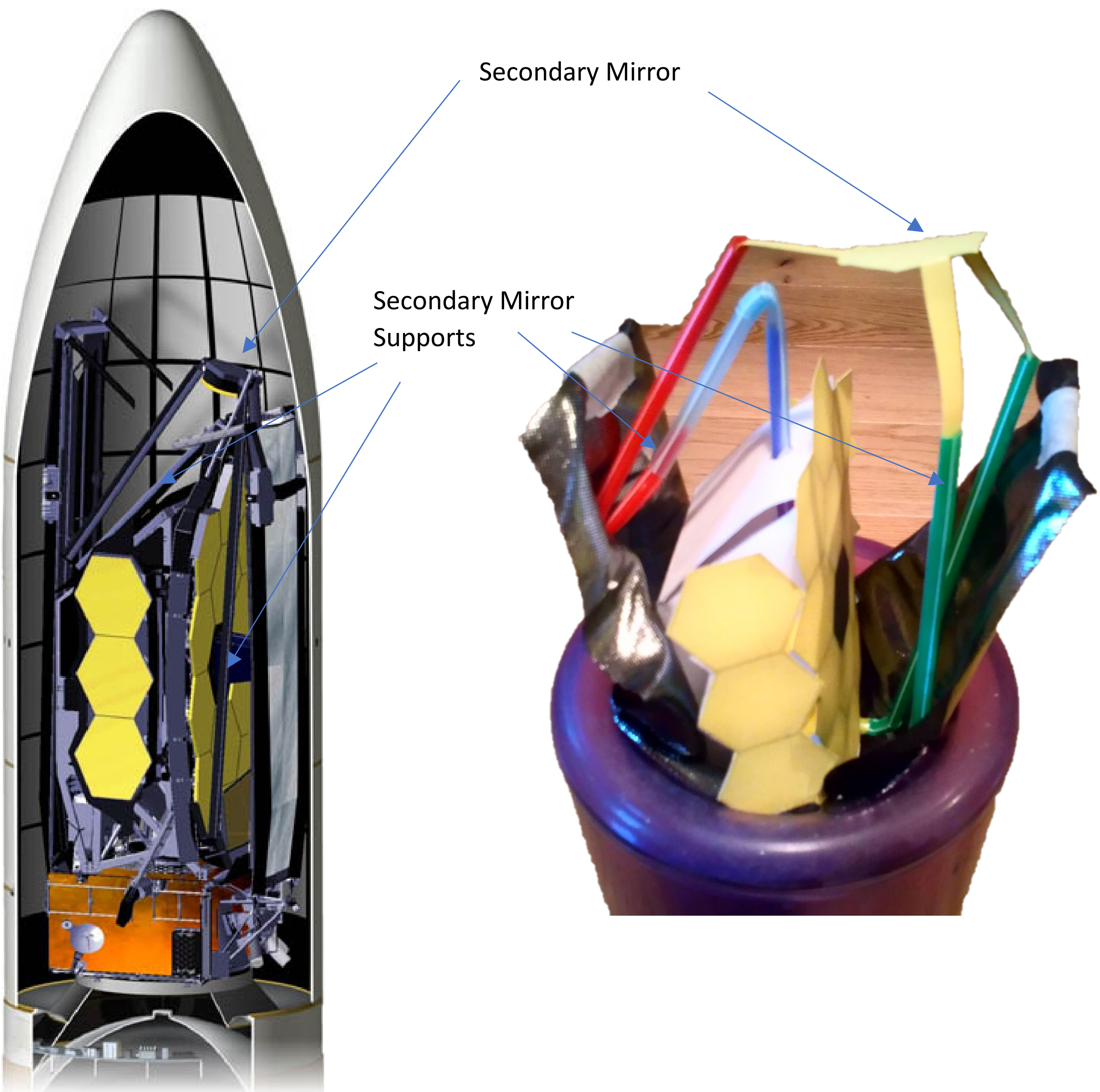
Make two **lower secondary mirror supports**. These each have a total length of 16 cm with a hinge 1 to 2 cm from the **ISIM**. These are connected by two shortened flexible straw segments that go through the **ISIM** (though holes A to A1 and B to B1) and connect at the back.

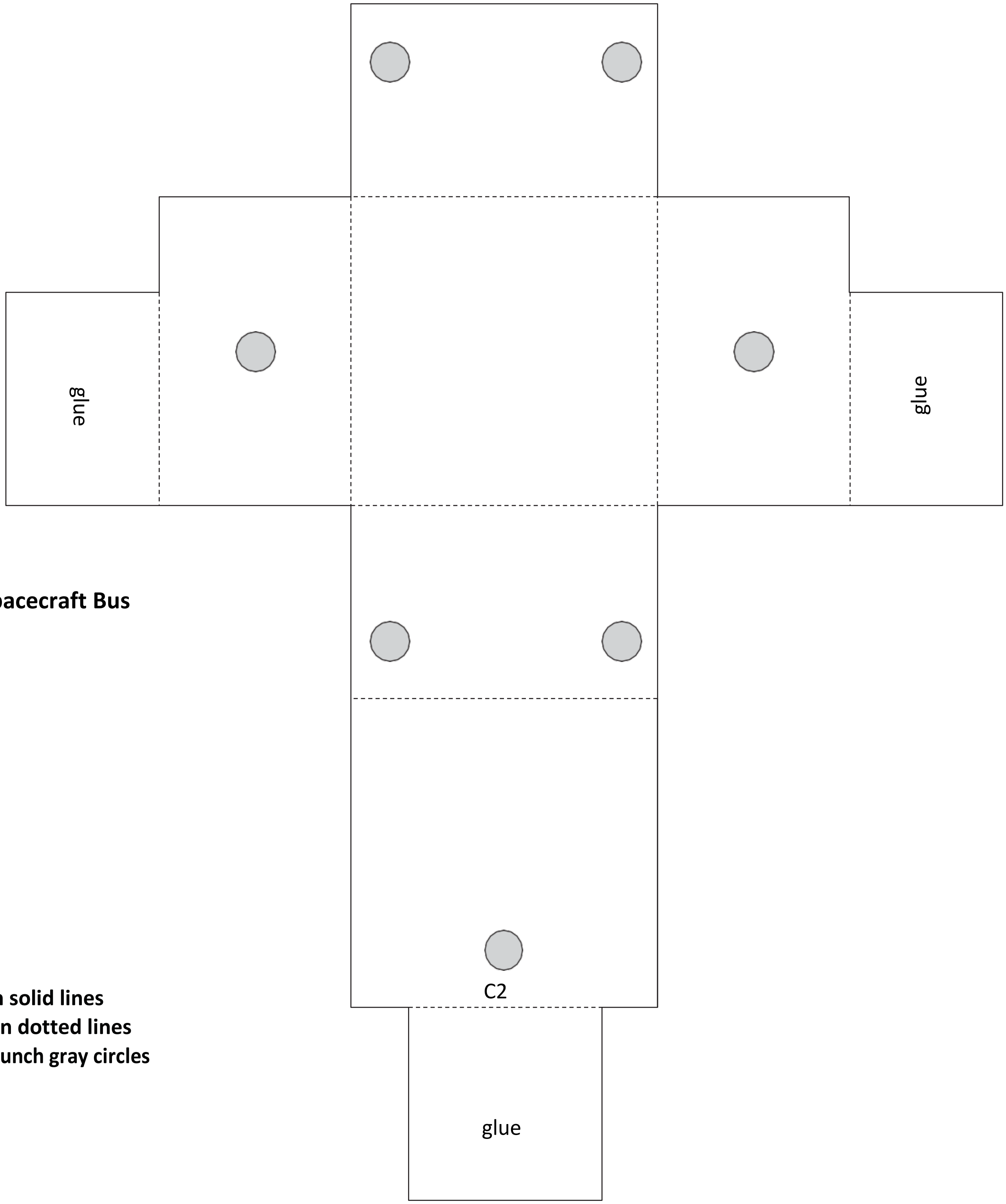
Make the **upper secondary mirror support**. This is 16 cm long with two hinges: one hinge above the **ISIM (X)**; one midway to the **secondary mirror (Y)**. It is connected to another straw that goes through the **ISIM** to the **spacecraft bus** (through holes C to C1 to C2 in the **spacecraft bus**).



4. Turn the **sunshield** over and mark and cut away the **sunshield** above the **spacecraft bus**.
5. Attach the **primary mirror** to the **ISIM**.
6. Attach the **secondary mirror** to the end of the **secondary mirror supports**.
7. Attach the **ISIM** to the **spacecraft bus**, aligning the straw that goes through the **ISIM** with hole C2 in the **spacecraft bus**.
8. Use one or two straws through the **spacecraft bus** to hold out the **sunshield** as **side sunshield supports.**
9. Cut off the end from a 2-litre soft drink bottle, fold up your model and place inside.
   To fold the model, remove the **side sunshield supports**, roll in the **sunshield**, lift and fold the **upper secondary mirror support** over the top of the **ISIM**. Fold in the sides of the **primary mirror**. Fold the **sunshield** up by bending the **sunshield supports** at the hinges by the **spacecraft bus**.

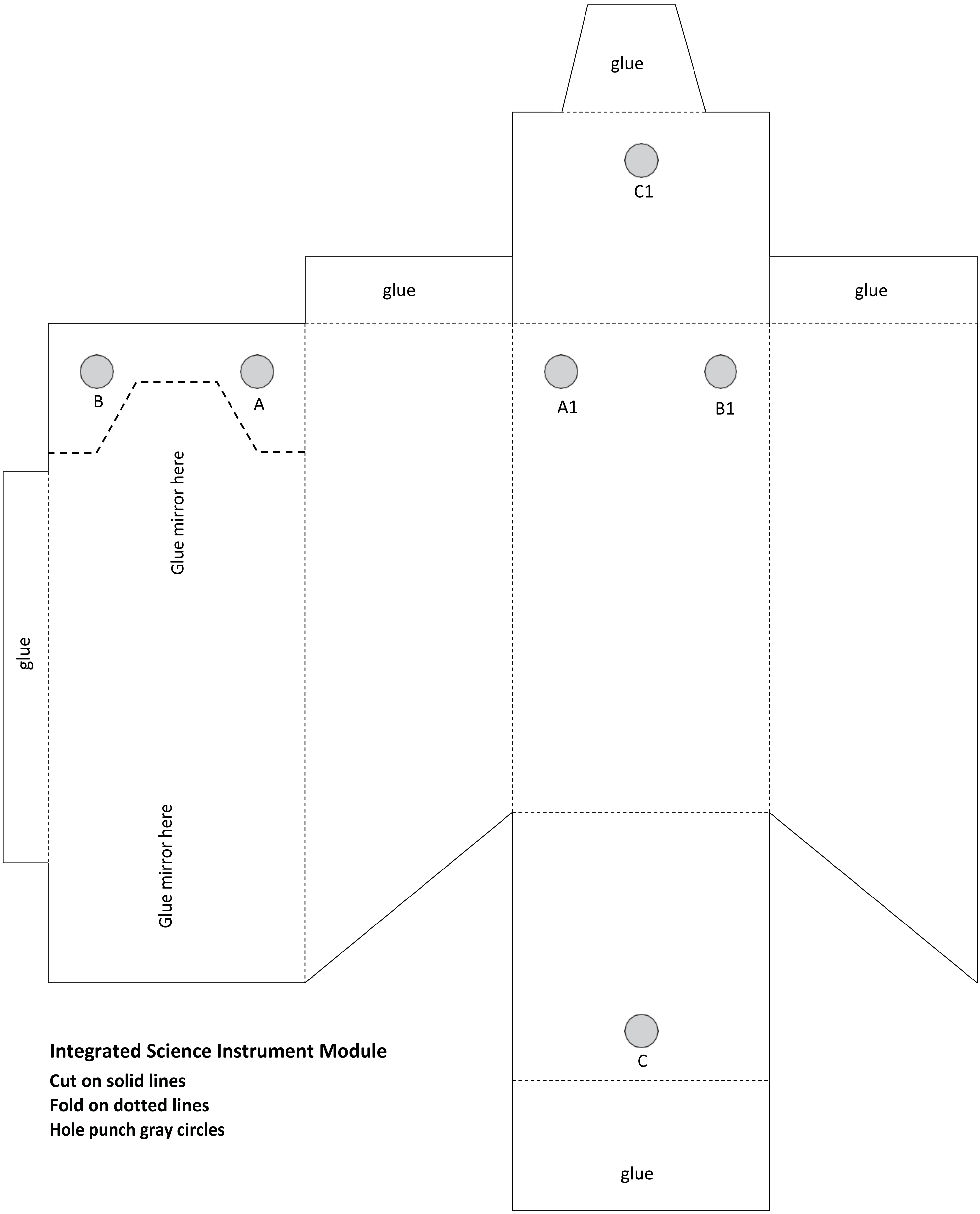
If you want to shake test your model – throw or shake the soft drink bottle.





Spacecraft Bus

Cut on solid lines
Fold on dotted lines
Hole punch gray circles

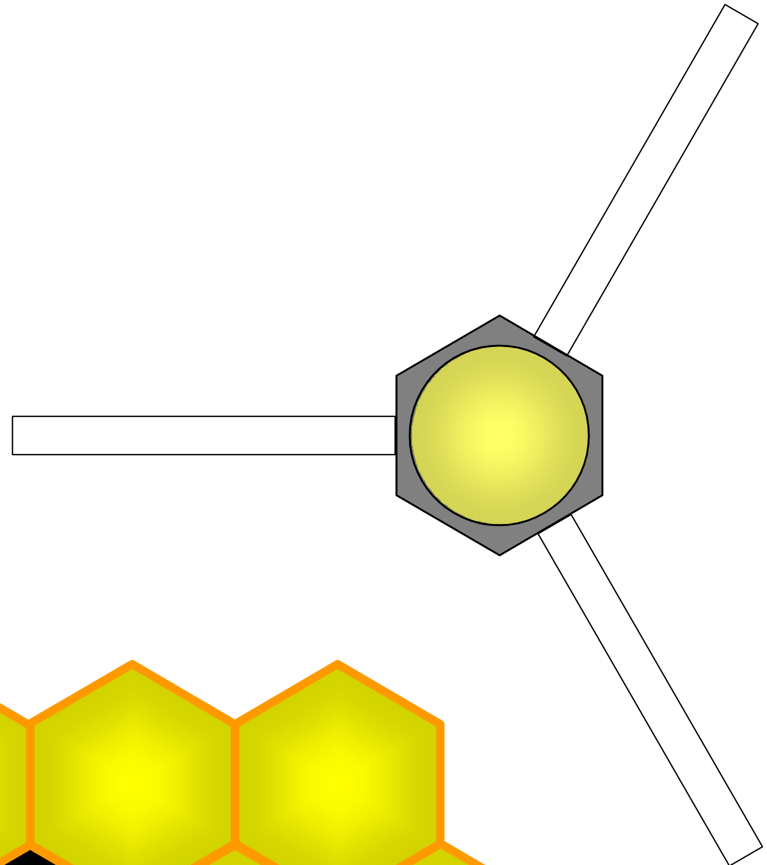


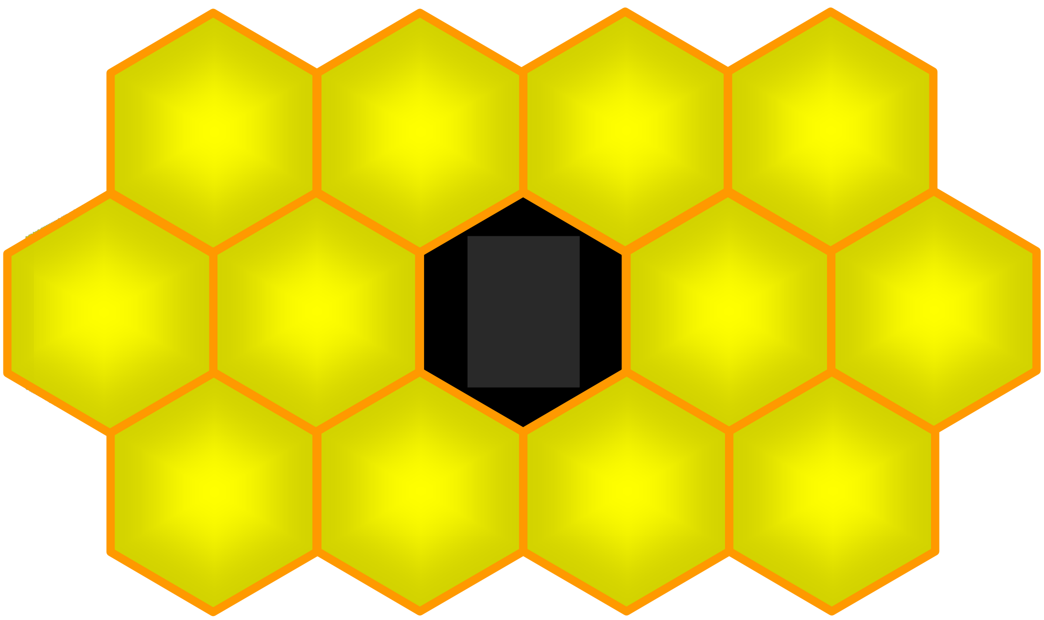
Integrated Science Instrument Module

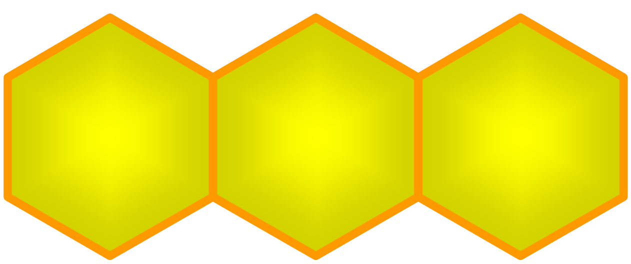
Cut on solid lines
Fold on dotted lines
Hole punch gray circles

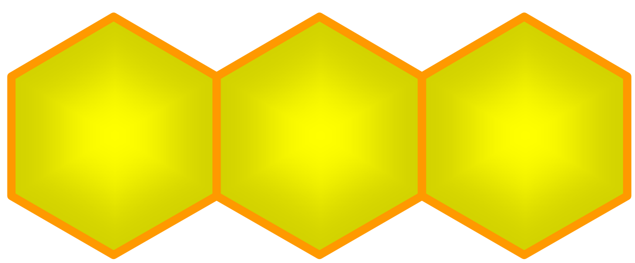
Primary and Secondary Mirrors

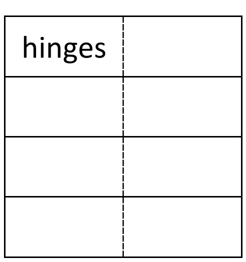
Cut out around edges











Cut hinges on solid lines

Fold on dotted lines

Adapted from James Webb Space Telescope — Deployment Demonstration Model
New Mexico Museum of Space History | Derived from model by John Jogerst (Non-commercial use only)

Template for sunshield

Cut on solid lines

1/2 of sunshield

place on fold

Adapted from James Webb Space Telescope — Deployment Demonstration Model
New Mexico Museum of Space History | Derived from model by John Jogerst (Non-commercial use only)

DPSM/ESERO

Framework for Inquiry - Promoting Inclusion

SPECIAL EDUCATION SUPPORT SERVICE
building on ability

When planning science activities for students with Special Educational Needs (SEN), a number of issues need to be considered. Careful planning for inclusion using the framework for inquiry should aim to engage students in science with real purpose. Potential areas of difficulty are identified below along with suggested strategies. This list is not exhaustive, further strategies are available in the Guidelines for Teachers of Students with General Learning Disabilities (NCCA, 2007).

ENGAGE

POTENTIAL AREA OF DIFFICULTY	STRATEGIES
Delayed language development/poor vocabulary/concepts	• Teach the language of science demonstrating meaning and/or using visual aids (material, property, strong, weak, textured, dimpled, absorbent, force, gravity). • Have the student demonstrate scientific phenomena, for example gravity —using 'give me, show me, make me,' as much as possible. • Assist the student in expressing ideas through scaffolding, verbalising a demonstration, modelling. • Use outdoor play to develop concepts.

INVESTIGATE

POTENTIAL AREA OF DIFFICULTY	STRATEGIES
Fear of failure/poor self-esteem/fear of taking risks	• Model the speculation of a range of answers/ideas. • Repeat and record suggestions from the students and refer back to them.
Understanding Time and Chronology	• Practice recording the passing of time, establish classroom routines that draw the students' attention to the measurement of time. • Teach and practice the language of time.
Fine/Gross Motor Difficulties	• Allow time to practice handling new equipment. • Allow additional time for drawing diagrams, making models etc. • Give students the option to explain work orally or in another format.
Short Term Memory	• Provide the student with visual clues/symbols which can be used to remind him/her of various stages of the investigation.

TAKE THE NEXT STEP

POTENTIAL AREA OF DIFFICULTY	STRATEGIES
Developing Ideas	• Keep ideas as simple as possible, use visuals as a reminder of earlier ideas. • Discuss ideas with the whole group. • Repeat and record suggestions from students and refer back to them. • Encourage work in small group and in pairs.
Communicating Ideas	• Ask students to describe observations verbally or nonverbally using an increasing vocabulary. • Display findings from investigations; sing, do drawings or take pictures. • Use ICT: simple written or word-processed accounts taking photographs, making video recordings of an investigation.

REFLECTION

- Did I take into account the individual learning needs of my students with SEN? What differentiation strategies worked well?
- Did I ensure that the lesson content was clear and that the materials used were appropriate?
- Was I aware of the pace at which students worked and the physical effort required?
- Are there cross curriculum opportunities here?
- Are the students moving on with their skills? Did the students enjoy the activity?

More strategies, resources and support available at **www.sess.ie**

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