

Activité 5 : Gaia, chasseur de planètes

Instructions : «Star in a box»

These instructions describe how to construct a star in a box which will allow students to plot light curves for a simulated exoplanet around a distant star without the need to black out the room. This set up allows existing light sensors or data loggers to be used and can easily be customised for any shape or make of light sensor. The instructions also detail how to adapt the set up to allow students to investigate the inverse square nature of light.



Equipment needed (per set up):

- One large sheet of thick black card (it is fine if it is only black on one side)
- One torch or circular LED light array approximately 5cm in diameter
- One light sensor/luxmeter
- One cardboard box big enough to cut two 8 cm radius circles from
- Cocktail stick, wooden skewer or thick wire to mount the exoplanet on
- Modelling clay/small polystyrene ball to act as an exoplanet
- A split pin
- A pair of compasses
- Ruler
- Pencil
- Craft knife
- Glue gun or epoxy
- Black material
- Protractor
- A copy of the star in a box template sheet

Method

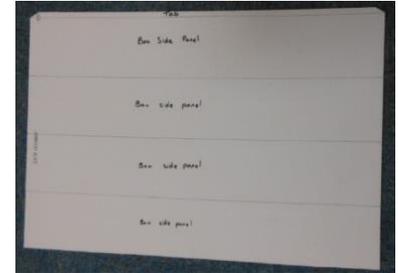
Using the star in a box template as a guide, draw out the components necessary on the thick black card.

Preparing the box:

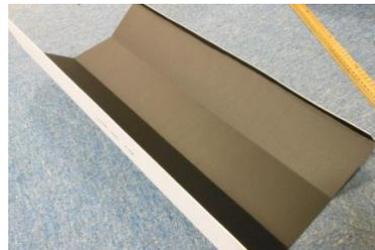
1. Using a craft knife and ruler, cut around the outside of the 4 side panel sections and tab being careful not to cut the individual panels out.

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2. Using a craft knife and ruler, carefully score along the lines between each side panel as well as the tab join. Gently bend along the scored lines. Make sure that the black side of the card is facing inwards.



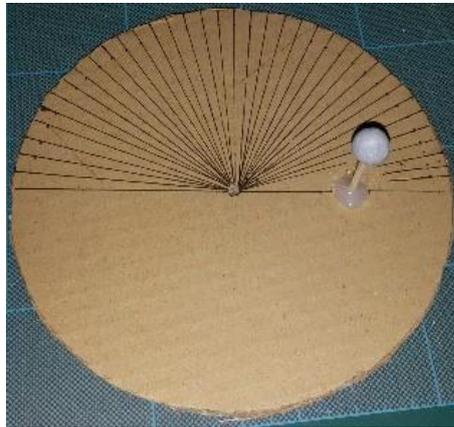
3. The next step is to prepare the revolving plate for the exoplanet to be mounted on. On thick card (a corrugated cardboard box is ideal for this), use the pair of compasses and a pencil to draw out 2 circles of radius 8cm and use a pin to push all the way through the card at the centre of the circle. Carefully cut both circles out with a craft knife. Glue the two circles together forming one thick circle and make sure that a pin can pass all the way through the centre of both layers.

4. Draw a line across the circle that passes through the centre splitting it into two 180° halves. Use a protractor and ruler to split one of the halves into 5° sections.

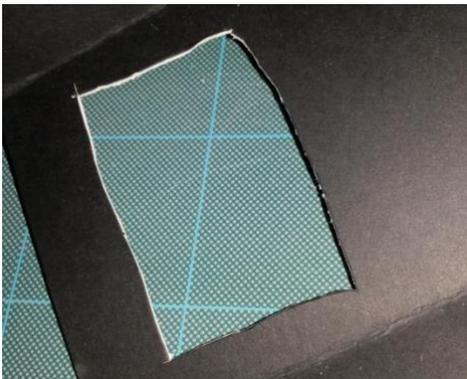
5. To make the exoplanet, cut a cocktail stick or wooden skewer a length of 6cm. Attach a modelling clay or polystyrene ball to the top of the flat end. Take the pointed end and choose a point on the centre line that is far enough away from the centre so as to allow the exoplanet to end up next to the torch. Use a glue gun or epoxy to further secure the exoplanet in place.

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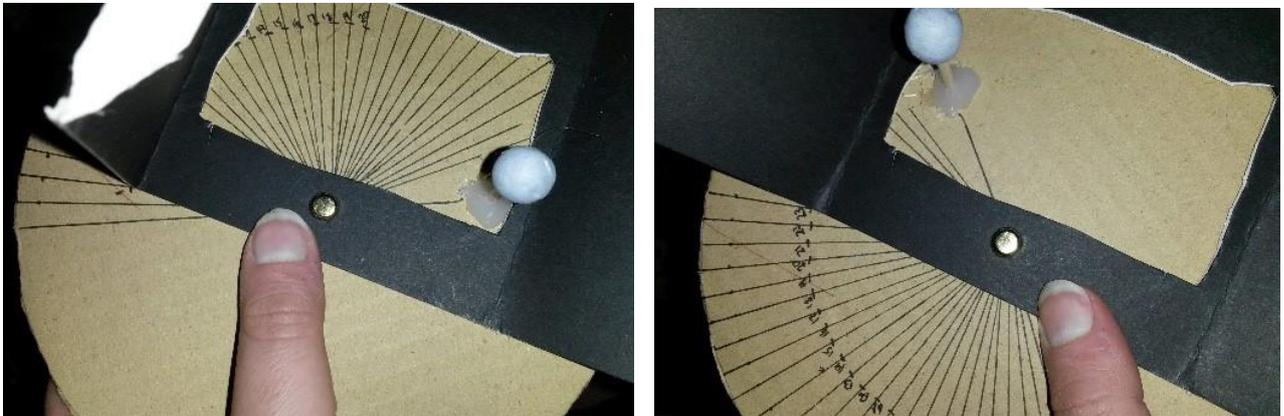
6. The circle will be pinned into place underneath the box using a split pin. Using a craft knife, carefully cut a section of the bottom of the box out so that the exoplanet will be able to orbit freely in front of the light. It is also important to make sure that the circle will be pinned as close to the front of the light as possible. Feed the exoplanet up through the cut out section, making with the 5° ruled section at the back of the box. Use a split pin to secure the circle to the bottom of the box.



7. Move the exoplanet so that it is as far to the right as it can go. Mark the point where the corner of the box intersects one of the ruled lines on the circle and label this 1. This will be the first position that will be measured. Turn the circle through 5° and again mark where the corner of the box intersects the line and mark this as 2 – the second measurement position. Repeat this process until the exoplanet has fully transited in front of the light and is touching the other side. This mark corresponds to the final reading to be taken.

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8. The rectangular tube is now ready to be glued. With a glue gun or epoxy, carefully glue the tab in place to form a tube, making sure that the black side of the card is facing inwards. If necessary, use tape to hold it in place while it dries.



Building the light mount:

The light mount will slot into one end of the box. It is designed to be removable so that you can easily access the battery compartment and swap the torch for a point source if you chose to use the equipment for an inverse square law experiment.

1. Now build the light mount. With a craft knife and ruler cut out the light mount shape from the card.
2. Carefully score along the dotted lines and bend along the score lines to form a cap that will fit into the rectangular box. Again, make sure that the black side is facing inwards.
3. Carefully draw around the light that will be used as a star making sure that the centre of the light will be at the centre of the square and with a craft knife, cut this shape out.
4. To give the star mount cap more strength, cut 4 small 4cm strips of card about the same width as the tabs, and score them in the middle to form corner joints. Using a glue gun or epoxy glue these in place in the corners of the light mount.
5. Insert the torch into the cut out section, making sure that the on button will be on the outside.

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Building the sensor mount:

1. With a craft knife and ruler cut out the sensor mount shape from the card.
2. Carefully score along the dotted lines and bend along the score lines to form a cap that will fit into the rectangular box. Again, make sure that the black side is facing inwards.
3. Carefully draw around the light sensor that will be used, making sure that the centre of the sensor is in the centre of the square and with a craft knife, cut this shape out.
4. To give the sensor mount cap more strength, cut 4 small 4cm strips of card about the same width as the tabs, and score them in the middle to form corner joints. Using a glue gun or epoxy glue these in place in the corners of the light mount.
5. Insert the sensor into the cut out section. Depending on the type of sensor you may need to add extra support to the outside of the mount to keep it aligned with the centre of the star.



Final assembly:

The star in a box is now ready to be slotted together. Carefully push the light mount into the end of the tube that has the exoplanet. In the opposite end, push in the sensor mount. If you do not intend to use the box for an inverse square law investigation you can glue the mounts in place and use thick black tape to cover along the seals making the box as light tight as possible. If you do intend to use the box for an inverse square law investigation as well, then simply use some black cloth to cover any gaps.

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Additional use – inverse square law

investigation:

This equipment is very easy to alter for an inverse square law of light investigation. It will however require the construction of a few extra components.

Point source mount:

In order to get as close to an inverse square relationship as possible, the light source needs to be as close to a small point source as possible. This can be achieved by making a cover for the torch with a small hole in to allow a pinpoint of light through. Alternatively, you can make a separate pinhole mount.

Note – this inverse square law experiment will only work with sensors that have a lead and as such can be placed at least half a metre from the device that displays the reading.

Building the pinhole mount:

1. With a craft knife and ruler cut out the pinhole mount shape from the card.
2. Carefully score along the dotted lines and bend along the score lines to form a cap that will fit into the rectangular box. Again, make sure that the black side is facing inwards.
3. Using a needle or the point of a very sharp knife make a small hole in the centre of the square.
4. To give the pinhole mount cap more strength, cut 4 small 4cm strips of card about the same width as the tabs, and score them in the middle to form corner joints. Using a glue gun or epoxy glue these in place in the corners of the pinhole mount.
5. Now a light source can be placed behind the mount and the pinhole will act as a point source. A torch with a single LED works best for this.

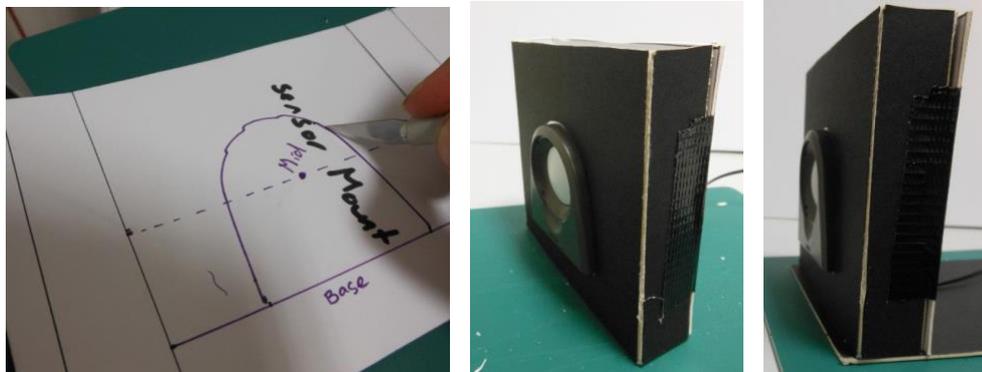
Building a moveable mount system for the sensor

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In order to investigate the inverse square law of light, the sensor will have to be able to move within the box.

1. Cut out the sensor base from the card with a craft knife and ruler. This base is sized to be slightly less wide than the box.
2. With a craft knife and ruler cut out the “sensor mount (inverse square law)” and carefully score along the tabs. Depending on your light sensor you may want to alter the depth of the mount to increase stability.
3. Position your sensor so that it is in the middle of one of the squares on the mount and draw around it. Repeat this with the other square and using a craft knife carefully cut out the shape.
4. Fold the box together with the black side pointing outwards and slide your sensor through the gap. If necessary it can be firmly secured in place with tape.
5. Take the sensor base and lay it out with the black side facing up. Glue the sensor mount on to the base, lining up the front of the mount with the front edge of the base.



6. The base will need to have a reference on for distance from the star. Lay the base with the sensor at the front along the top of the star box. Measure a distance of 10cm from the end of the star box and place the front of the sensor at this point. Holding the base in place, mark on the other end of the base where it first overhangs the other end of the box. Make a mark here and label it 10cm. This means that when you pull the base out to this point, the sensor will be 10cm from the light source. Repeat this procedure for 5cm increments of distance from the front of the box.

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7. Remove the original sensor mount from the box and carefully slide the base with sensor into the box until the 10cm mark is reached. Since this sensor mount is purposefully designed to be slightly smaller than the box it will be necessary to place black material over the open end to reduce unwanted light interfering with readings.