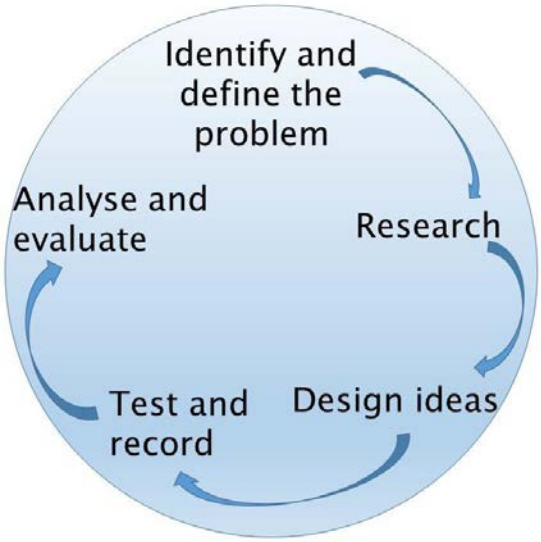
How to use this document

1. Open this file in Adobe Reader. If you do not have this program you can download it for free here: https://acrobat.adobe.com/au/en/acrobat/pdf-reader.html
2. Download the file and **save** it as Project Name _Your Name e.g. Going for Gold_Joe Bloggs **It is really important you do this otherwise none of your input will be saved.**
3. Fill in your answers in the text boxes
4. Where there are image boxes take photos/scans of your work and upload the picture file. If you cannot do this upload the pictures as separate files and save them as Project Name_Your Name_Image number e.g. Going for Gold_Joe Bloggs_Image 1
5. Save your work as you go along
6. When you have finished email/upload as your teacher has instructed.

The Challenge

A school has decided to build a new Science, Technology, Engineering and Mathematics (STEM) facility and has asked students for design ideas. They hope the building will be environmentally friendly and cost effective.



Background Information

A passive building is one that requires minimal energy input but maintains a comfortable temperature year-round. There are a few important things which must be considered when designing a passive building. These include its orientation, shading, insulation, seals, windows, and the building materials used. Many councils will either send someone out to you or can send you equipment you can use to take measurements at different locations in your building to determine how passive and energy efficient it is. This will involve taking measurements at different times of the day and in different locations around the building, as well as completing a building inspection to look at the different materials used.

The more passive the building the more energy efficient it is, this means that less energy is needed for heating, cooling and lighting. A passive design is desirable as, not only does it greatly reduce electricity and gas bills, it is better for the environment.

Background Research

Using the Australian Government website: http://www.yourhome.gov.au/passive-design and any others you find useful, research passive design and answer the questions below.

1. Why does the orientation of a building make a big difference to how much light it gets?

   Suggested site: http://www.yourhome.gov.au/passive-design/orientation

2. How might the orientation of a passive building in the northern hemisphere compare to that of a passive building in the southern hemisphere?

   Suggested site: https://greenpassivesolar.com/passive-solar/building-characteristics/orientation-south-facing-windows/

3. What does thermal mass mean?

   Suggested site: http://www.yourhome.gov.au/passive-design/thermal-mass

4. Give examples of building materials with high thermal mass.

   Suggested site: https://www.smarterhomes.org.nz/smart-guides/design/thermal-mass-for-heating-and-cooling/

5. What are some ways of shading your house? Draw diagrams to show how they work. Attach this as a separate file or insert below.

Suggested site: http://www.yourhome.gov.au/passive-design/shading

6. Why are deciduous trees favourable in passive design for shading?

Suggested site: http://www.yourhome.gov.au/passive-design/shading

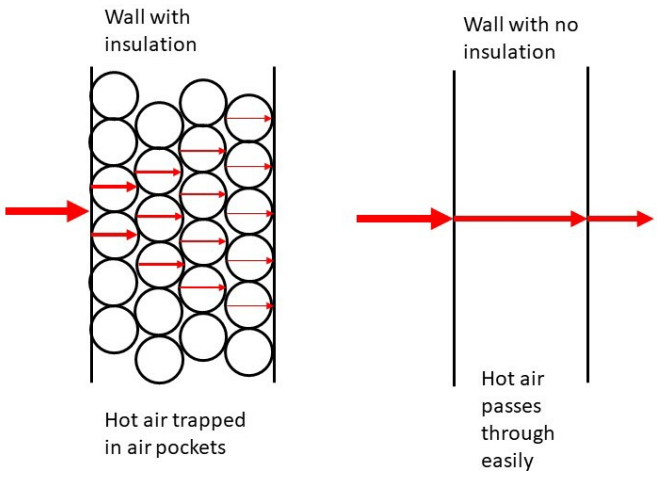
7. What are the advantages and disadvantages of having lots of windows on a building?

Advantages	Disadvantages

Suggested site: http://www.yourhome.gov.au/passive-design/orientation

Investigating Insulation

Most buildings have insulation in their roofs, and some will even have insulation in their walls. Insulation traps hot air which means less heat is lost to the outside in winter, and heat cannot enter in the summer. This helps to keep the building at a desirable temperature all year round, without having to use heating or air conditioning. There are many different types of insulation, natural and man-made, such as sheep's wool, polystyrene, expansion foam and wool fibre.



Objective

To investigate the efficiency of different types of insulation.

Equipment

- 4 x materials to be used as insulation
- Jar with lid (all the same size)
- Thermometer
- Ice-cold water
- Permanent marker or white-out

Method

1. Wrap the jar in an insulating material.
2. Pour in ice-cold water and draw a line showing how much you put in.
3. Place the thermometer into the jar.
4. Record the initial temperature of the water in the table provided.
5. Every minute give the water a swirl and record its temperature, putting the lid back on the jar between readings.
6. Repeat step 5 for 10 minutes.
7. Repeat the investigation for all insulation types, making sure you use the same volume of water each time.

Results and Analysis

Time (min)	Material 1 (°C)	Material 2 (°C)	Material 3 (°C)	Material 4 (°C)
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

1. Which material had the smallest change in temperature, and what was the change?

2. Which material was the most efficient insulator?

3. Which material had the largest change in temperature and what was the change?

4. Which material was the least efficient at insulating?

Evaluation

1. Was the thickness of the insulating material the same for each material type? Could this have impacted your results?

2. Why was it important to swirl the water before each measurement?

3. Do you think this was a fair test, explain your answer?

4. What improvements could be made to the test? (Explain why these improvements would make the investigation better).

5. What kind of jobs might require you to know about different types of insulation, and who might find this information important?

Investigating Thermal Mass

The thermal mass of a material (also known as its specific mass) will determine how long it takes to heat up and cool down. A material with a high thermal mass takes a long time to heat up, but once heated will retain the heat for a long time. It is good to build with materials which have a high thermal mass as it means in the winter the material will heat up during the day and will stay warm through the night and in the summer it will take a long time for the material to heat up.

Objective:

To determine which building material has the highest thermal mass.

Materials

- A range of building materials e.g. brick, tiles, concrete, slate, glass, wood
- Ice cubes
- Stopwatch
- 1 x jar/ cup/ glass for each material, make sure they are all the same size
- Hot water source
- Measuring jug

Method

1. Pour 400ml of hot water into each beaker (make sure each is the same temperature).
2. Place each building material to be tested on top of a glass (so it is heated from below).
3. Place an ice cube on top of each of the building materials.
4. Observe and record how long it takes for the ice cube to melt on each piece of material.

Results and Analysis

1. On which material did the ice take longest to melt on?

2. On which material did the ice melt the quickest?

3. Which material had the highest thermal mass?

4. Which material had the lowest thermal mass?

5. Which material would be best to use to ensure passive design? Explain your answer.

Evaluation

1. Were all your pieces of ice the same size at the start?

2. Were all your building materials in an area of equal light and heat, or were some closer to heat sources than others?

3. Were all your materials similar thickness?

4. Was your experiment fair? Explain your answer.

5. What changes could you make to your investigation to improve it?

6. What kind of jobs might require you to know about thermal mass and why would this information be useful?

Investigating Colour

The colour of a building can impact how much warmth it absorbs. In Australia, because it is generally so hot, it is more desirable for a building to reflect solar radiation.

Objective

To investigate the impact of colour on how quickly a material heats up.

Materials

- Tin cans painted different colours, or wrapped in different colour paper (black, white and silver)
- Thermometer
- Sun
- Measuring jug

Method

1. Pour water into a can recording the volume you added.
2. Place the thermometer into the can
3. Measure the temperature of the water.
4. Place can out in the full Sun.
5. Swirl the can before taking readings of the temperature every 30 seconds for five minutes and record the results in the table.
6. Repeat the investigation for the other colours of cans ensuring you use the same volume of water each time.

Results and Analysis

Complete the table below

Time (min)	Temperature of black test tube (°C)	Temperature of silver test tube (°C)	Temperature of white test tube (°C)
0			
0.5			
1			
1.5			
2			
2.5			
3			
3.5			
4			
4.5			
5			

	black test tube (°C)	silver test tube (°C)	white test tube (°C)
Total change in temperature (temperature at 5 minutes – temperature at 0 minutes			

1. Which can had the largest change in temperature?

2. Which can showed the smallest change in temperature?

3. What colour would you recommend painting your house to ensure a passive design? Explain your answer?

Evaluation

1. Did you use the same volume of water in each can?

2. Why was it important to swirl the water before taking a temperature reading?

3. Was your experiment a fair test? Explain your answer.

4. What improvements would you make to your investigation?

5. Other than in the building trade, who else could find this information useful for their job? Explain your answer.

Critique of a Building

Objective

To critique the design of an existing building and suggest areas for improvement to make it a more passive design.

1. Choose a building which you can complete an environmental assessment of. Complete the table below, adding in notes and any extra detail which will help you to write a report.

Building name/number	
Building location	
Orientation (which way the windows are facing)	
Shading (eaves, trees etc.)	
Sealing (tight doors and windows etc)	
Insulation	
Thermal mass of building material (high, medium, low)	
Windows (large, small, single, double or triple glazed)	
Colour (building, tiles)	
Other	

2. Take photos which will help support your report, for example of the eaves, the colour of the building, which way the windows are facing etc. Attach these as separate documents or insert them below.

3. For the building you investigated complete the following (include photos if possible):

Building name/number:

Passive design features (positives):

Non-passive design features (negatives):

Suggestions to improve the building (make it more passive):

Design a Passive Building

Objective:

To design a passive building. You can complete this as a report with sketches and photos, or using Computer Assisted Design (CAD).

Considering the main factors which affect how passive a building can be:

1. What orientation will your building have (which way will it face)?

2. Will you have eaves, and if so how big will they be?

3. What other types of shading will you have?

4. What building materials would you use?

5. What type of windows would you install?

6. How will you ensure tight seals around entrances?

7. Will you use any insulation, and if so what kind?

Step 1. Draw the four faces of the building, adding a scale, any colours and annotations, such as building material type. Attach these as a separate document or on the next page.

Figure 1

Figure 2

Step 2. Draw a cross – section of the building (as if you had cut the building in half and opened it up), showing the walls and any insulation used. Attach this as a separate document.

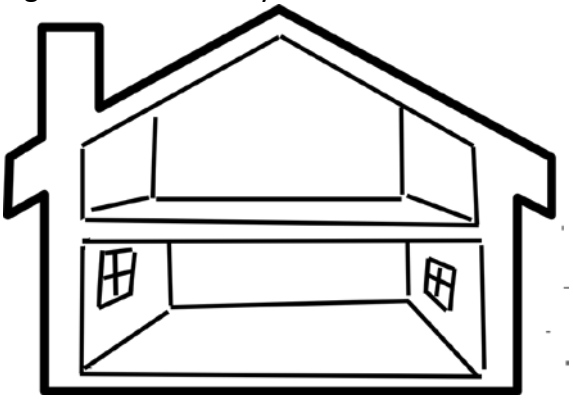
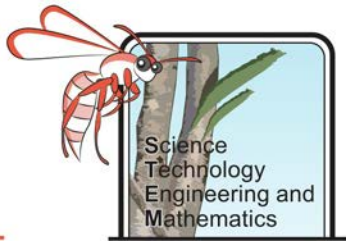


Figure 3

Step 3. Draw a plan of your building, showing how big the rooms will be, and if it is open plan or not. You will need to draw a plan for each level, if your building is more than 1 story high.
Make sure you have labeled each design feature you have added, such as insulation/shading etc. Attach this as a separate document or on the next page.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