Design and Technologies
Book 8

Towards Zero
Designing for Sustainability

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DESIGN AND TECHNOLOGIES
AND
DIGITAL TECHNOLOGIES

LAPtek

Book 8

Towards Zero -
Designing for sustainability

ENGINEERING PRINCIPLES AND SYSTEMS

and

MATERIALS AND TECHNOLOGIES SPECIALISATIONS

STEM - D

Designing for sustainability requires that we reduce or better still eliminate the amount of carbon being emitted into the atmosphere from human activities. Reducing carbon can be achieved by designing and creating carbon zero homes and working environments.

Creating carbon zero homes is cost effective and takes carefully planned application of Passive solar heating, Passive cooling, Hot water service; Renewable energy, Permaculture, Composting, Aquaponics and then applying that understanding to buildings and infrastructure.

The terms ‘carbon zero’ or ‘zero emission’ apply to homes and work environments that use renewable energy sources to generate energy for their day to day operation, so that over twelve months the net amount of energy generated on site equals the net amount of energy required by the home.

Steven Penna

Student Learning Guide & Record

Task	Page	Description	Date completed	Instructor's signature
Task 1	5	Summarise photovoltaic cells		
Task 2	7	Summarise photovoltaic cells		
Task 3	11	Explain how you would best utilise the benefits of passive heating and cooling		
Task 4	16	Producing alternating current and sine wave form		
Task 5	19	Explain how a supercapacitor works (multi-media presentation)		
Task 6	22	Learn to use drawing software		
Task 7	60	Write a design brief		
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Task 15	74	Make a scale model of your preferred design option		
Task 16	74	Justification of preferred option		
Task 17	75	Production plan		
Task 18	78	Design a solar car and solar charger		
Task 19	78	Save as a STL file and send it to the printer		
Task 20	82	Make a solar car and solar charger		
Task 21	85	Measure voltage, current and power from solar collector		
Task 22	85	Measure voltage and current of your operational solar charger		
Task 23	95	Review questions – Environmental sustainability		
Task 24	99	Visit EPA website – Greenhouse animation		
Task 25	102	Visit EPA website – Carbon footprint animation		
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TOWARDS ZERO – DESIGNING FOR SUSTAINABILITY

CLIENT – PLANET EARTH

Towards Zero - Designing for Sustainability is an approach that encourages innovation and puts the well-being of people and the sustainability of the environment first. We want you to design a lifestyle to which no more can be consumed, than can respectively be regrown, regenerated, and provided again in the future, a lifestyle that is sustainable

Placing sustainability of the environment first will ensure future generations and other living beings will not face drastic and irreversible disadvantages.

This Designing for Sustainability workbook introduces you to specialist knowledge and design practices and principles that are articulated through a series of individual and team-based design projects.

The workbook introduces you to new knowledge, the design process and ways of researching and reporting the environmental and social impacts of your design. This will be via: methods such as:

- Life Cycle Thinking.
- Product and process autopsies.
- Life Cycle Assessment (LCA).
- Design of sustainable and integrated systems.

You will learn to work within the parameters of a design process through research, concept drawings, sketch modelling, and various methods of design visualisation. Your design projects will culminate in detailed CAD and project documentation and will be prototyped via digital and manual processes.

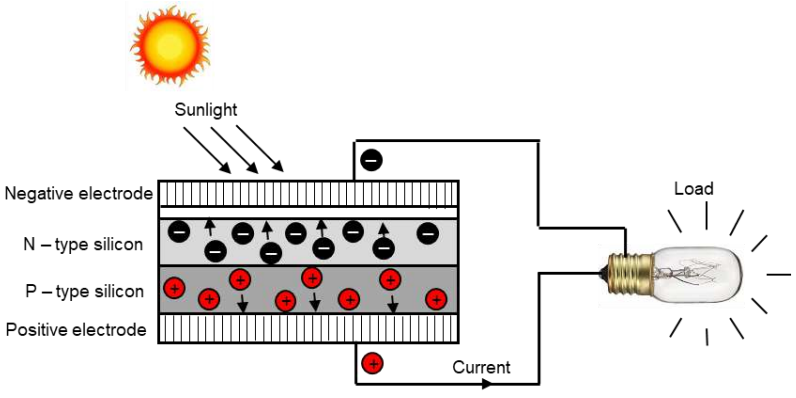
SOLAR ENERGY

PHOTOVOLTAIC CELL

Photovoltaic cells (PV) are used to convert the sun's rays into electricity. The light we can see has a medium amount of energy and is made up of tiny bits of energy called photons. Photons shoot out of atoms whenever their electrons change position in a particular way. This is electromagnetic radiation.

How Photovoltaic Cells Work

The diagram on the right illustrates the operation of a basic photovoltaic cell. The PV cell contains two layers of semiconducting material, one with a negative charge and the other with a positive charge. When sunlight strikes the cell, some photons are absorbed by semiconductor atoms, freeing electrons that travel from the negative layer of the cell back to the positive layer, in the process creating a voltage. The flow of electrons through an external circuit produces electricity.



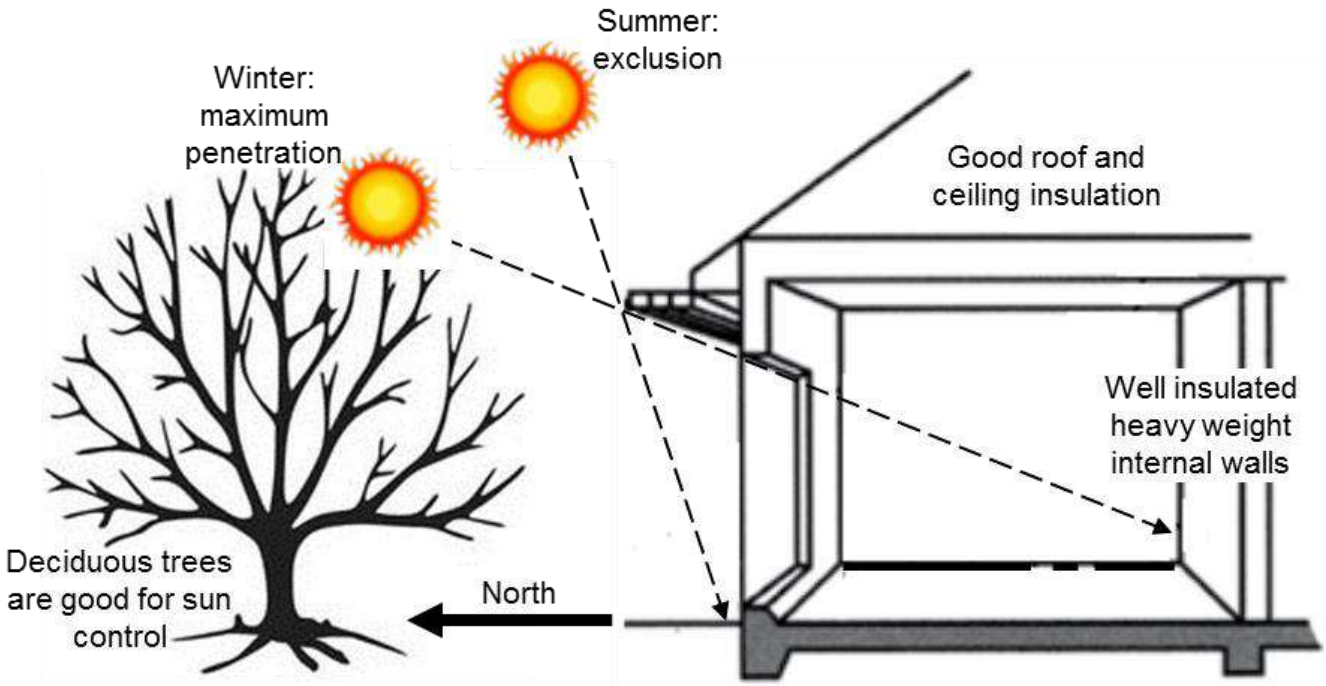
The sunlight striking the cell is converted into electricity

How passive solar heating works

Solar radiation is trapped by the greenhouse action of correctly oriented (north-facing) glass areas exposed to full sun. Window orientation, shading, frames and glazing type have a significant effect on the efficiency of this process.

Trapped heat is absorbed and stored by materials with high thermal mass (usually masonry) inside the building. It is re-released at night when it is needed to offset heat losses to lower outdoor temperatures.

Passive solar heating is used in conjunction with passive shading, which allows maximum winter solar gain and prevents summer overheating. This is most simply achieved with northerly orientation of appropriate areas of glass and well-designed eaves overhangs.



Passive shading features can control the entry of sunlight and wind.

Re-radiated heat is distributed to where it is needed through good design of air flow and convection. Direct re-radiation is most effective but heat is also conducted through building materials and distributed by air movement. Floor plans should be designed to ensure that the most important rooms (usually day-use living areas) face north and receive the best winter solar access.

Heat loss is minimised with appropriate window treatments and well-insulated walls, ceilings and raised floors. Thermal mass (the storage system) must be insulated to be effective. Slab-on-ground edges should be insulated in colder climates, or when in-slab heating or cooling is installed within the slab.

Air infiltration is minimised with airlocks, draught sealing, airtight construction detailing and quality windows and doors.

Appropriate house shape and room layout is important to minimise heat loss, which takes place from all parts of the building, but mostly through the roof. In cool and cold climates, compact shapes that minimise roof and external wall area are more efficient. As the climate gets warmer more external wall area is appropriate, to allow for better cross-ventilation.

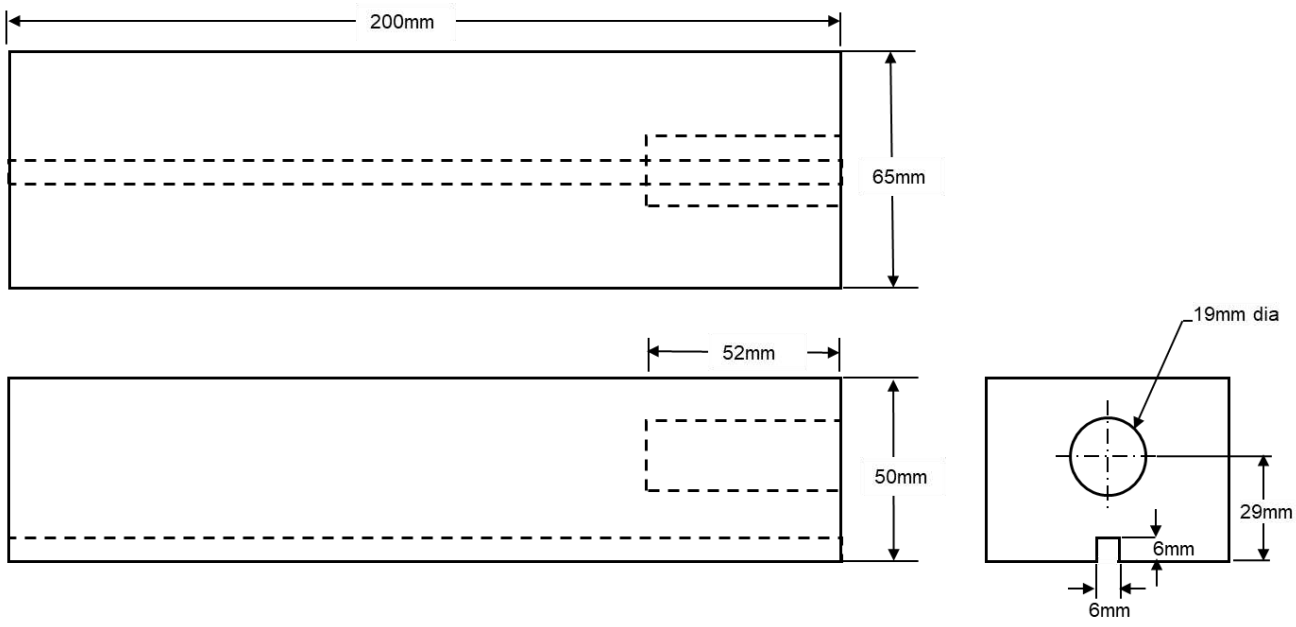
TASK 6: LEARN TO USE DRAWING SOFTWARE

Before you commence designing your solar car and solar charger you will need to be conversant with a drawing package. For this task we will be using 'Fusion 360. You will learn to work within the parameters of 'Fusion 360' whilst designing a F1 racing car. When you have completed the following steps you should have enough skill to draw the components required for your solar car and solar charger.

How: Open Autodesk Fusion 360 or a similar drawing software provided by your teacher to produce a 3D model of a basic F1 racing car.

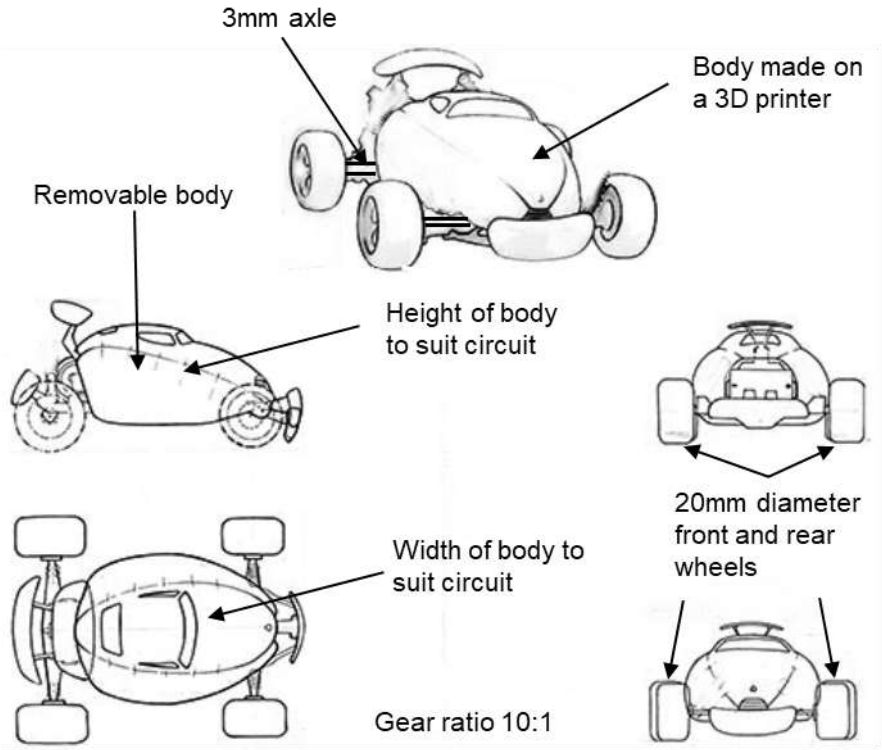
F1 design by Stewart Kneeshaw

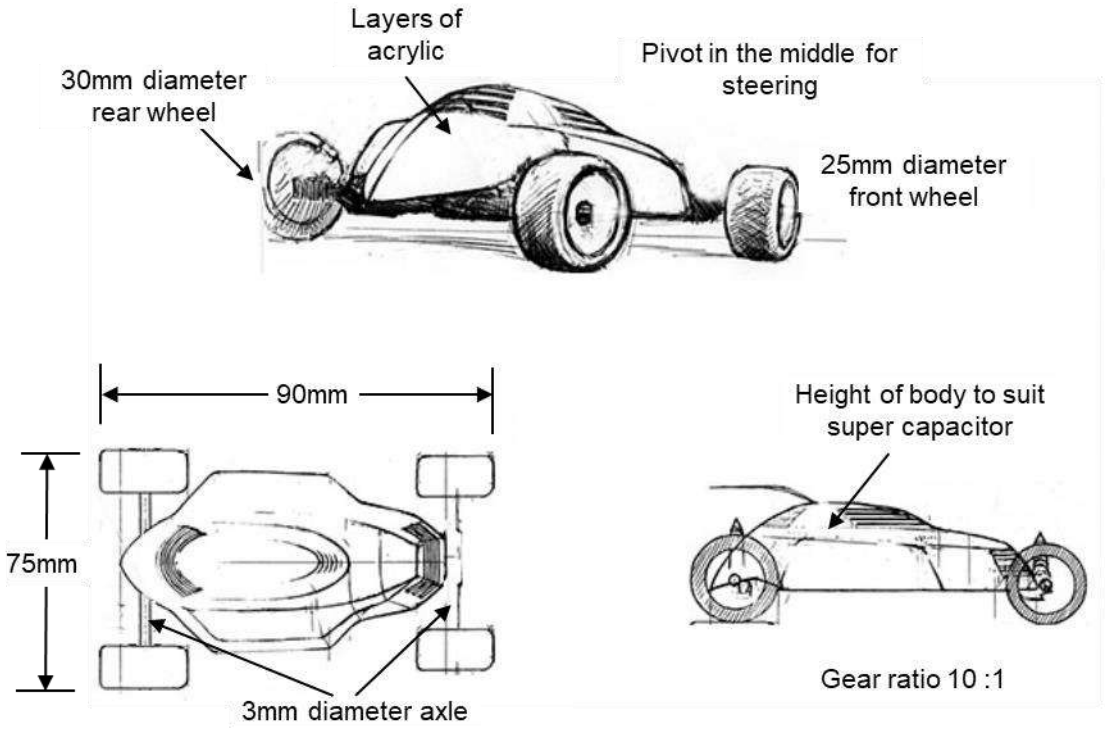
Size constraints for your F1 Racing Car



CONCEPT DRAWINGS

Concept drawings are rough drawings, representing the chief features of an object. They are generated to rapidly explore a wide range of ideas and quickly identify and explore opportunities for innovation. Below are concept drawings for a crocodile. Note the annotations and the range of innovative ideas produced by the designer.





Concept drawings of a car

THE CARBON FOOTPRINT

The carbon footprint the total set of greenhouse gas emissions caused directly and indirectly by an individual, event, organisation or product, expressed as Tonnes of greenhouse gas (Tonnes ghg)

The full carbon footprint of an organisation encompasses a wide range of emission sources, from direct use of fuels to indirect impacts such as employee travel or emissions from other organisations in the supply chain.

A common categorising method is to group greenhouse gas emissions by the level of control an organisation has over them. On this basis, the are three types of greenhouse classifications are Direct emissions, Electricity usage and Indirect emissions.

1. Direct emissions

Direct emissions are the emissions produced by the on-site combustion of fuels, emission of gasses during operation, production and manufacture, and running of a vehicle fleet.

Direct emissions

2. Electricity usage

Electricity usage is the electricity used for lighting, heating, and powering of equipment.

Although the organisation is not directly in control of the emissions, by using the electricity it is indirectly responsible for the release of CO_2.

Electricity usage

3. Indirect emissions

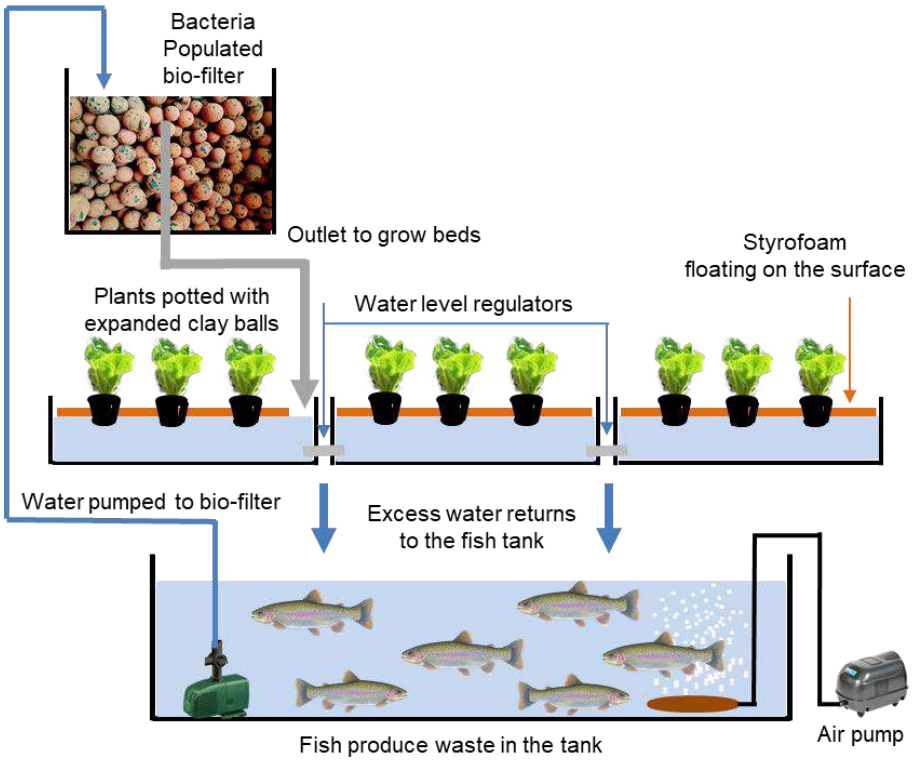
Indirect emissions are the emissions that are emitted in the preparation and transport of the raw materials.

Indirect emissions

AQUAPONICS

Aquaponics is used to grow food crops in a concentrated, yet sustainable manner. Nutrient rich water from a fish tank is recirculated through a vegetable grow bed. Nutrients from the fish waste feed the plants, and the plants filter the water to keep the fish healthy and the water fresh. The two main components of the system are the fish tank and the grow beds. A small pump moves water to the grow beds. The water passes through the roots of the plants before draining back into the fish tank. The plants extract the water and nutrients (fish waste) they need to grow, cleaning the water for the fish. There are a number of different styles of grow bed designs, the two most common being flood and drain and floating raft style.

From a nutritional standpoint, aquaponics provides food in the form of both protein (from the fish) and vegetables.



Floating aquaponic set-up

How Aquaponics Works

The main input to an aquaponic system is fish food. The fish eat the food and excrete waste. More than 50% of the waste produced by fish is in the form of ammonia secreted in the urine and, in small quantities, through the gills. The remainder of the waste, excreted as faecal matter, undergoes a process called mineralization which occurs when heterotrophic bacteria consume fish waste, decaying plant matter and un-eaten food, converting all three to ammonia and other compounds.

Nitrifying bacteria, which naturally live in the soil, water and air, convert ammonia first to nitrite and then to nitrate which plants consume.

In an aquaponic system the heterotrophic and nitrifying bacteria will attach to the tank walls, underside of the rafts, organic matter, the growing medium (if used) and in the water column.

The beneficial bacteria are natural and will inhabit an aquaponic system as soon as ammonia and nitrite are present.

Trout grown in aquaponic system

