THEME 4

Earth and Space Exploration

What is the method used to send reusable launch vehicles into the orbit of the International Space Station (ISS)? Is it by direct transfer or through Hohmann transfer orbit?

CHAPTER 9

SPACE TECHNOLOGY

What are the types of orbits of Malaysian satellites which orbit Earth?

Dato' Dr. Sheikh Muszaphar Shukor Al Masrie bin Sheikh Mustapha is the first Malaysian astronaut to carry out scientific research at the International Space Station (ISS). How many days was he at the ISS?

What is the final type of orbit taken by launch vehicles which carry astronauts, supplies and satellite equipment to reach the ISS?

Let's study

- Satellite
- Global Positioning System (GPS)

Science Bulletin

Malaysia is among the first Asian countries to launch a 5G demonstration project

Is 5G network currently used in telecommunications in Malaysia? 5G network, together with Global Satellite Network technologies, has clearly and widely benefited all parties all over the world.

The Global Satellite Network enables the worldwide transfer of information from one country to another while 5G network is able to decipher the type of data required by local users. 5G network is also able to switch to lower level power when not in use and switch back to higher level power for purposes such as high-definition video streaming.

Advancements in telecommunication technology widens the use of satellites in daily life. Name the satellite owned by Malaysia which can be used in the demonstration of 5G in this region.

Source:
http://buku-teks.com/sc5235
(Medium: *bahasa Melayu*)

Keywords

- Type of satellite orbit
- Low Earth Orbit (LEO)
- Middle Earth Orbit (MEO)
- High Earth Orbit (HEO)
- Geosynchronous Orbit (GSO)
- Geostationary Orbit (GEO)
- Apogee
- Perigee
- Orbital height
- Satellite speed
- Hohmann transfer orbit
- Expendable launch vehicle (ELV)
- Reusable launch vehicle (RLV)
- International Space Station (ISS)
- Zero gravity
- Space junk
- Global Positioning System (GPS)
- Navigation
- GPS coordinates
- DMS format
- DD format
- Google Maps
- Waze

9.1 Satellite

A **satellite** is an object which orbits planets or stars. For example, the Moon is a natural satellite which orbits Earth. Besides natural satellites, there are many man-made satellites which orbit Earth.

Types of Satellite Orbits

The orbits of satellites which circle Earth are grouped into **five** types according to orbital height (altitude) (Figure 9.1).

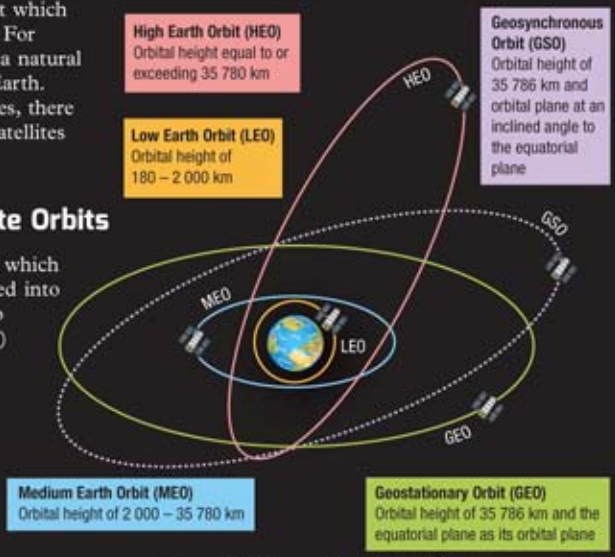


Figure 9.1 Types of satellite orbits

Activity 9.1

21st Century Skills
- ICS
- Discussion

To gather information and explain the types of satellite orbits

Instructions

1. Carry out this activity in groups.
2. Gather information from the Internet, print media and other electronic media about the types of satellite orbits, namely LEO, MEO, HEO, GSO and GEO.

   Examples of reference websites are as follows:

   Geosynchronous Orbit (GSO) and Geostationary Orbit (GEO)
   http://buku-teks.com/sc5236a

   Catalogue of types of satellite orbits
   http://buku-teks.com/sc5236b
3. Discuss the information that you gathered.
4. Present the outcome of your group discussion to the class.

Orbital Shapes

There are two orbital shapes, perfectly circular and elliptical (Figure 9.2). GEO is an example of a perfectly circular orbit while MEO and HEO are examples of elliptical orbits. LEO and GSO are perfectly circular or elliptical.

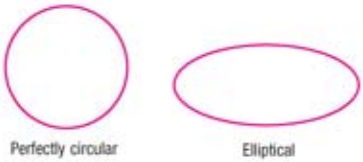


Figure 9.2 Orbital shapes

Apogee and Perigee of a Satellite in an Elliptical Orbit

For satellites which make elliptical orbits, there are two specific positions in the orbits, which are **apogee** and **perigee** (Figure 9.3).

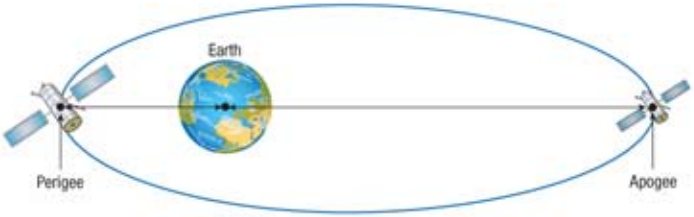


Figure 9.3 Apogee and perigee of a satellite in an elliptical orbit

The **apogee** of a satellite in an **elliptical orbit** is the **position of the satellite** which is **furthest** from the planets or stars encircled by the satellite. How about the perigee of a satellite in an elliptical orbit?

Relationship between Orbital Height and Satellite Velocity

The types of satellite orbits, orbital heights and satellite speeds are shown in Figure 9.4.

Figure 9.4 Examples of types of satellites, orbital heights and satellite speeds

The higher the orbital height of a satellite, the lower the satellite speed for it to remain in orbit. This is because the gravitational force on a satellite decreases when the orbital height of the satellite increases.

9.1.1 9.1.2 9.1.3

What will happen to a satellite moving in a fixed orbit if its speed reduces too much? How about if its speed increases too much?

Let us carry out Activity 9.2 to identify the relationship between orbital height and satellite speed.

Thinking Skills

Visit the following website to collect information about the height or altitude of satellite orbits for satellite's GPS purposes.
http://buku-teks.com/sc5238a

Activity 9.2

21st Century Skills
- TPS, ICS
- Inquiry-based activity

To draw a conclusion on the relationship between orbital height and satellite speed

Instructions

1. Carry out this activity in groups.
2. Gather information from the Internet, print media and other electronic media about the types or systems of satellites, orbital heights and satellite speeds.
3. Tabulate the information and data gathered on orbital heights and satellite speeds.
4. Analyse the data gathered and draw a conclusion on the relationship between a satellite's orbital height and its speed.
5. Present your group's conclusion to the class.

Example:

Satellite	Type of satellite orbit	Orbital height (km)	Satellite speed
	GEO		
	MEO		
ISS	LEO		

Launch and Placement of Satellite into Orbit

Let us carry out Activity 9.3 to understand how a satellite is launched and placed into orbit directly or through Hohmann transfer orbit.

Activity 9.3

21st Century Skills
- ICS
- Inquiry-based activity

To explain how a satellite is placed into orbit

Instructions

1. Carry out this activity in groups.
2. Gather information from watching the following video clip to explain how satellites are placed into orbit directly or through Hohmann transfer orbit.

   Watch the following video clip:
   http://buku-teks.com/sc5238b
   Start time 5:00/10:05
   End time 9:14/10:05
3. Discuss your observations after watching the video.
4. Present the way satellites are placed into orbit as observed from the video to the class.

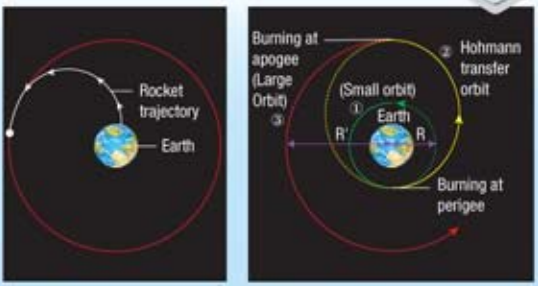
Click@Web

Launch and placement of satellite into orbit
http://buku-teks.com/sc5238c

Methods of Sending Launch Vehicles into Orbit

Scan AR Page

Launch vehicles, which are made up of one or more rockets, are used to send satellites or spacecrafts into outer space. Figure 9.5 shows two ways to place satellites into orbits using launch vehicles.



(a) Directly into orbit (b) Hohmann transfer orbit

Figure 9.5 Ways to send launch vehicles into orbit

Launch vehicles are divided into **two** types:
(a) expendable launch vehicle (ELV)
(b) reusable launch vehicle (RLV)

Photograph 9.1 Launching of ELV and RLV by NASA

Let us carry out Activity 9.4 to look for information about the differences between ELV and RLV.

Activity 9.4

21st Century Skills
- TPS, ICS
- Inquiry-based activity

To differentiate ELV from RLV

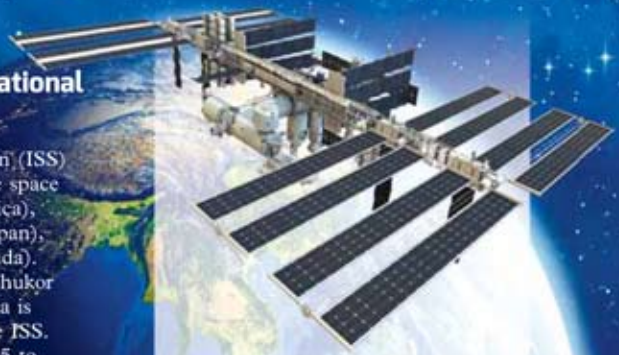
Instructions

1. Carry out this activity in groups.
2. Gather information from the Internet, print media and other electronic media about the differences between expendable launch vehicle (ELV) and reusable launch vehicle (RLV).
3. Present the differences between ELV and RLV using a multimedia presentation to the class.

Function of the International Space Station

The International Space Station (ISS) is the result of efforts from five space agencies namely NASA (America), Roscosmos (Russia), JAXA (Japan), ESA (Europe) and CSA (Canada). Dato' Dr. Sheikh Muszaphar Shukor Al Masrie bin Sheikh Mustapha is the first Malaysian to reach the ISS.

Let us carry out Activity 9.5 to understand the functions and lives of astronauts on the ISS.



Photograph 9.2 The International Space Station (ISS)

Click@Web

What is the International Space Station (ISS)?
http://buku-teks.com/sc5240a

Activity 9.5

21st Century Skills
- ICS
- Inquiry-based activity

To understand the functions of the ISS and the lives of astronauts on the ISS

Instructions

1. Carry out this activity in groups.
2. Gather information from watching the following videos about space stations such as the ISS, its functions and the lives of astronauts on this space station.

   Examples of reference websites are as follows:

   Functions of the ISS
   http://buku-teks.com/sc5240b

   Lives of astronauts on the ISS
   http://buku-teks.com/sc5240c

   Zero gravity or microgravity
   http://buku-teks.com/sc5240d
3. Discuss the information that you gathered.
4. Present the outcome of your group discussion to the class.

Zero gravity is the condition when no significant gravitational force effect is felt. For example, the condition in indoor skydiving (Photograph 9.3). Participants of indoor skydiving will float in air and feel a condition of zero gravity. This condition occurs because the thrust produced by a very strong flow of air upwards on the participants is equal in value to their weight but in the opposite direction. As such, no significant gravitational force is felt.

Photograph 9.3 Zero gravity in indoor skydiving

Methods for Tracking Space Stations

The frequency of the ISS orbiting Earth in a day can be calculated by using its orbital height and speed.

Activity 9.6

21st Century Skills
- ICS, TPS
- Inquiry-based activity

To calculate the frequency of the ISS orbiting Earth in a day

Instructions

1. Carry out this activity in groups.
2. Use the data of orbital height and speed of the ISS in Activity 9.2 as well as radius of Earth (6.37×10^6 m) to calculate the frequency of the ISS orbiting Earth in a day.

$$\text{Period of orbit, } T = \frac{\text{Length of orbit}}{\text{Speed of satellite}}$$

$$= \frac{2\pi \times (\text{Orbital height} + \text{Radius of Earth})}{\text{Speed of satellite}}$$

$$\text{Frequency of the ISS orbiting Earth in a day} = \frac{86\,400 \text{ s (1 day)}}{\text{Period of orbit, } T}$$

3. Present the outcome of your group calculations to the class.

Tracking the Position of Space Stations Using Smartphone Applications

Observe and identify the position of the ISS and the observer in the photograph from the smartphone screenshot (Figure 9.6).

Figure 9.6 Screenshot on smartphone which shows the location of the observer, the ISS and its orbit

Impact of Rapid Development in Space Technology

Among the impacts of rapid development in space technology are:

(a) **Increased waste in space (space junk)**
Waste in space or space junk are non-functioning satellites, used parts of ELV, satellite debris from collisions between satellites, exhausted rockets and other waste.

According to observations made by parties monitoring space junk from NASA, 95% of thousands of man-made objects in low Earth orbit are waste in space. The more space junk there is, the higher the risk of collision of satellites with space junk. This explains why the weather satellite, GOES, normally changes its orbit several times to avoid collision with space junk.

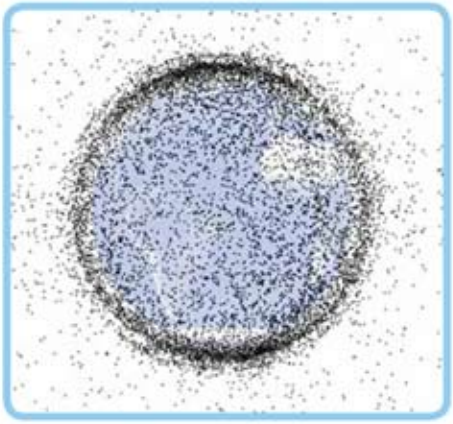


Figure 9.7 Space junk at geosynchronous orbit, GSO (Each dot represents a satellite or space junk)

(b) **Increase in research and development activities**
Advancement and development in space technology have increased activities in research and development in various fields such as human health, response towards climate change and disasters, new innovative technology, global education and development in space economy.

Activity 9.7

21st Century Skills
- ICS
- Discussion

To gather information related to the impact of rapid development in space technology

Instructions

1. Carry out this activity in groups.
2. Gather information from the Internet, print media and other electronic media on the impact of rapid development in space technology such as:
   (a) increase in space junk
   (b) increase in research and development activities in various fields in the life and health of humans
3. Discuss the information that you have gathered.
4. Present the outcome of your group discussion to the class.

Formative Practice 9.1

1. State **five** types of satellite orbits.
2. (a) Draw a diagram to show the apogee and perigee of a satellite in an elliptical orbit.
   (b) Explain the apogee and perigee of a satellite in an elliptical orbit.
3. What is the relationship between orbital height and satellite velocity?
4. What is Hohmann transfer orbit?
5. Why are astronauts at the ISS in a floating condition?
6. Give your views on the impact of increase in space junk.

9.2 Global Positioning System (GPS)

Global Positioning System (GPS) is a navigation system which gives information on **location** and **time** to its users in all weather conditions.

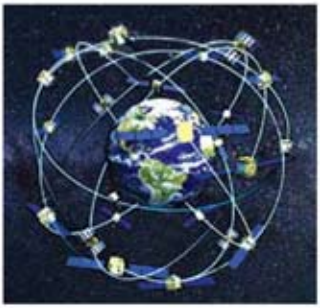


Figure 9.8 Illustration of a GPS satellite network (Image © NOAA)

How GPS Functions

GPS is made up of **three** segments, the control segment, space segment and user segment.

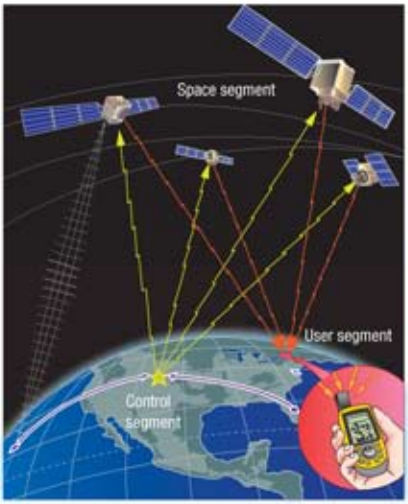


Figure 9.9 How GPS functions

Control Segment

The control segment is made up of a master control station, alternative master control station, command and control antennas as well as monitor stations. Signals received by the monitor stations from the GPS satellite are sent to the master control station which will generate navigation messages on Earth (Figure 9.10). The information sent from the antenna on Earth to the GPS satellite includes the GPS satellite position, time correction factor for the GPS satellite clock, atmospheric data and almanac.

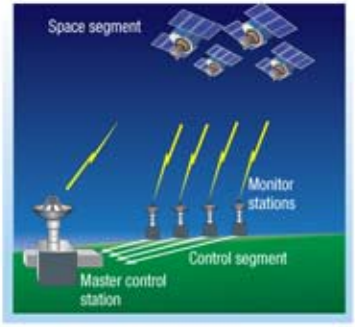


Figure 9.10 Control segment and space segment in GPS

Space Segment

GPS is made up of a satellite network. GPS satellites orbit Earth at an orbital height of 20 000 km. The orbit of a GPS satellite is usually known as a semi-synchronous Earth orbit (Figure 9.11) with an orbital period of about 12 hours.

At least 4 GPS satellites can be seen at an angle of 15° or more from the horizontal axis at any time from all locations on Earth (Figure 9.12). The information sent from the GPS satellite to the GPS receiving device includes the position of the GPS satellite and the time the signal is sent.

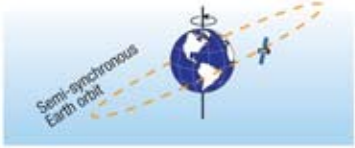


Figure 9.11 GPS satellite orbit

Figure 9.12 Positions of GPS satellites and GPS user

User Segment

A GPS user is anyone who uses a GPS receiving device such as a smartphone. The location of a place can be written in two formats as follows:

(a) Degrees, minutes and seconds (DMS)
(b) Decimal degree (DD)

5°26'25"N 100°18'32"E
Georgetown, Pulau Pinang

Figure 9.13 GPS coordinates in DMS format

GPS coordinates can be written in two formats, namely DMS and DD.

Example

GPS coordinate:

(a) National Planetarium, Kuala Lumpur

DMS format coordinates : 3°08'22.04"N (Latitude) 101°41'22.53"E (Longitude)
DD format coordinates : 3.139456 101.689593

Positive value represents latitude in the **northern** hemisphere

Positive value represents longitude to the **east** of Greenwich Meridian

(b) Copacabana, Rio de Janeiro

DMS format coordinates : 22°58'14.60"S (Latitude) 43°10'56.51"W (Longitude)
DD format coordinates : – 22.970722 – 43.182365

Negative value represents latitude in the **southern** hemisphere

Negative value represents longitude to the **west** of Greenwich Meridian

The directions 'East' and 'West' on the GPS coordinates in DMS format are based on the Greenwich Meridian.

Science Info

Calculator for the two GPS coordinate formats
http://buku-teks.com/sc5245

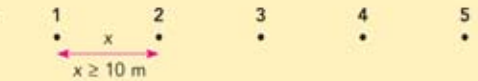
Activity 9.8

21st Century Skills
• Inquiry-based activity

To navigate from one location to another within the school using GPS coordinates

Instructions

1. Carry out this activity in groups in an open area in school such as the school field.
2. Mark five locations with a minimum distance of 10 m between each location in the open area of the school.



3. Use a GPS receiving device such as a smartphone to determine the GPS coordinates at each location.

4. Observe and record the coordinates for the five locations in the following formats:
   (a) Degrees, minutes and seconds (DMS)
   (b) Decimal degree (DD)

Result

Location	x (m)	GPS coordinates in DMS	GPS coordinates in DD
1			
2			
3			
4			
5			

Questions

1. Why is this activity carried out in an open space and not in class?
2. What is the main purpose of using GPS coordinates?
3. Name **two** examples of navigation applications which use the GPS coordinate system in daily life.

Uses of GPS

GPS is used for navigational purposes in various types of transport such as land, sea, air and space transport. Examples of applications of navigation which use GPS coordinates are Google Maps and Waze.

Photograph 9.4 Screenshots of Google Maps and Waze

Click@Web

Navigational applications (Animation)
http://buku-teks.com/sc5247a

Find Pizza (Video)
http://buku-teks.com/sc5247b

Activity 9.9

21st Century Skills
- TPS, ICS
- Inquiry-based activity

To study the Global Positioning System (GPS)

Instructions

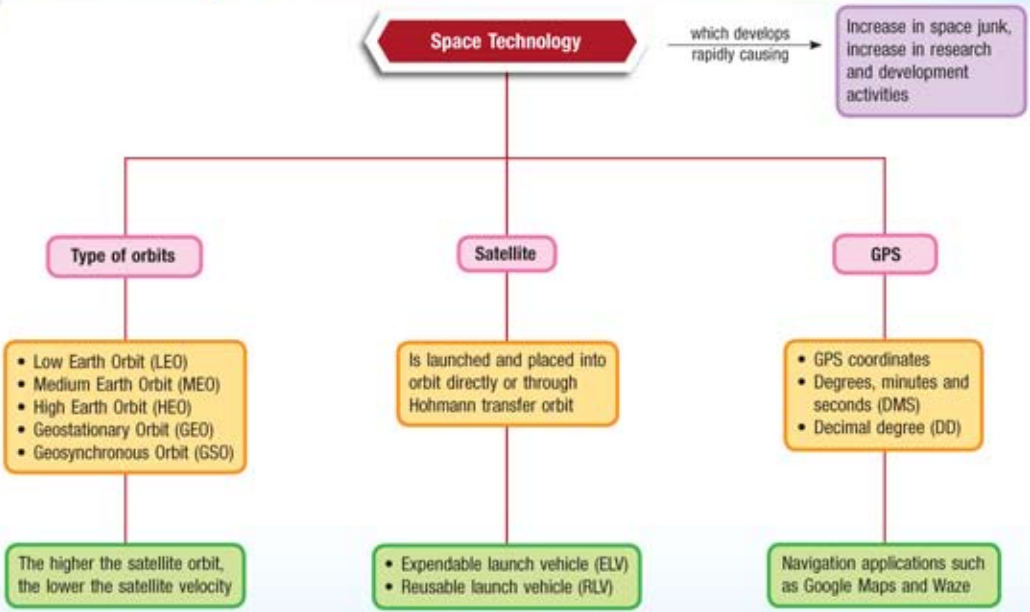
1. Carry out this activity in groups.
2. Gather information from various sources on the meaning of GPS, how GPS functions and the uses of GPS.
3. Discuss the information that you have gathered.
4. Present the outcome of your group discussion to the class using a multimedia presentation.

Photograph 9.5 Car GPS tracker

Formative Practice 9.2

1. What is the meaning of Global Positioning System (GPS)?
2. How does GPS function?
3. What are the uses of GPS?
4. What are the benefits of notifications of road accidents in navigational applications to road users?

Summary


Space Technology
which develops rapidly causing
Increase in space junk, increase in research and development activities
Type of orbits
Satellite
GPS
• Low Earth Orbit (LEO)
• Medium Earth Orbit (MEO)
• High Earth Orbit (HEO)
• Geostationary Orbit (GEO)
• Geosynchronous Orbit (GSO)
Is launched and placed into orbit directly or through Hohmann transfer orbit
• GPS coordinates
• Degrees, minutes and seconds (DMS)
• Decimal degree (DD)
The higher the satellite orbit, the lower the satellite velocity
• Expendable launch vehicle (ELV)
• Reusable launch vehicle (RLV)
Navigation applications such as Google Maps and Waze

Self-Reflection

After studying this chapter, you are able to:

9.1 Satellite

- ☐ Explain the types of satellite orbits.
- ☐ Explain with diagrams the apogee and perigee of a satellite in an elliptical orbit.
- ☐ Relate the height of an orbit with the velocity of a satellite.
- ☐ Explain how a satellite is launched and placed into orbit.
- ☐ Explain the function of a space station.
- ☐ Communicate about the methods for tracking space stations.
- ☐ Elaborate the impact of rapid development in space technology.

9.2 Global Positioning System (GPS)

- ☐ Explain Global Positioning System (GPS).
- ☐ Apply the GPS coordinate system for navigational purposes.

Summative Practice 9

Quiz
http://buku-teks.com/sc5249

Answer the following questions:

1. Figure 1 shows an example of the orbit for satellite X which has an orbital period of 12 hours.

Figure 1

(a) Based on Figure 1, name the type of satellite X.
(b) Give **one** example of application of satellite X.

2. (a) State **three** features of a GPS satellite.
(b) Give **one** example of a device which contains a GPS receiver.
(c) Name **one** use of GPS in daily life.
(d) Give **two** examples of navigational application which use GPS satellite.

3. Figure 2 shows different types of satellite orbits labelled A, B, C and D.

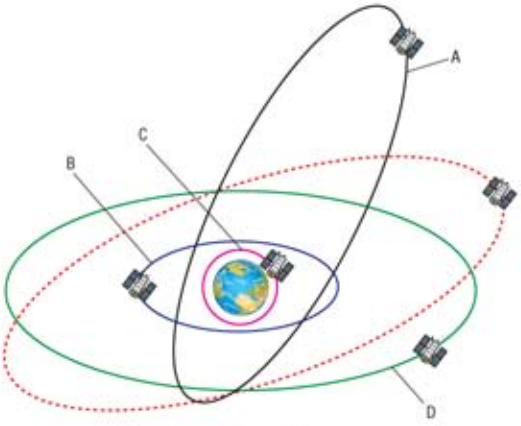


Figure 2

(a) Label the types of orbits in Figure 2 with the following abbreviations.

GEO	HEO	LEO	MEO

(b) Based on Figure 2, name the type of orbit for GPS satellites.

Enrichment Practice

4. The clock in a GPS satellite needs to be adjusted from time to time.
What is the importance of accurate time information from GPS satellites in our daily activities?

Answers

Only selected answers are provided here

CHAPTER 1 Microorganisms

Summative Practice 1

1. (a) The higher the concentration of the antibiotic, the larger the area of the clear region.
   (b) (i) Type of bacteria, surrounding temperature
   (ii) Concentration of antibiotic
   (c) Antibiotics can kill bacteria.
2. (a)

Have cell wall and cell membrane	Have no cell wall and cell membrane
P, Q, R, T	S

   (b) Virus
   (c) (i) Yeast
   (ii) Microorganism P is a useful microorganism because it is used to make food such as bread. Microorganism P is not a pathogen because it does not cause disease.

CHAPTER 2 Nutrition and Food Technology

Summative Practice 2

1. (a) Consumption of whale meat can warm the body compared to other food.
   (b) (i) **Aim of experiment**
   To measure and compare the calorific values of fat, carbohydrate and protein
   (ii) **Identification of variables**
   - Manipulated variable: Type of food sample
   - Responding variable: Rise in temperature
   - Constant variable: Mass of water in calorimeter

   (iii) **List of materials and apparatus**
   - Materials: Fat, carbohydrate and protein samples weighing 1 g each, distilled water and cotton wool
   - Apparatus: Retort stand, boiling tube, thermometer, shield, plasticine and needle

CHAPTER 3 Sustainability of the Environment

Summative Practice 3

1. (a) River water is the most polluted water sample compared to tap water, distilled water and pond water.
   (b) (i) Volume of water
   (ii) Type of water sample
   (c) River water
   (d) The higher the level of water pollution, the shorter the time taken for the methylene blue solution to decolourise.
2. (a) Paper bag
   (b) Paper takes a much shorter time to disintegrate.
   (c) Microplastic is a plastic piece measuring less than 5 mm in length.
   (d) Plastic bottle, plastic bag, plastic container, man-made textile, paint (any two)

CHAPTER 4 Rate of Reaction

Summative Practice 4

1. (a) Process where one or more reactants are converted into one or more products.
   (b) Yes.
   Pressure affects the reaction for reactants in the gaseous state.
2. (a) (i) Size of marble chips/calcium carbonate
   (ii) Volume of gas collected
   (iii) Concentration of hydrochloric acid, volume of hydrochloric acid and mass of marble chips
   (b) The smaller the size of marble chips/ calcium carbonate, the higher the rate of reaction.

CHAPTER 5 Carbon Compounds

Summative Practice 5

1. (a) Fermentation
   (b) Organic carbon compound
   (c) Limewater turns cloudy
   (d) Carbon dioxide is released in the reaction between sugar and yeast.
2. (a) Atherosclerosis
   (b) Cholesterol
   (c) Saturated fats

(d) 1. Reduce the intake of fatty food
2. Eat unsaturated fats which can reduce the level of cholesterol in blood
(any suitable answer)

CHAPTER 6 Electrochemistry

Summative Practice 6

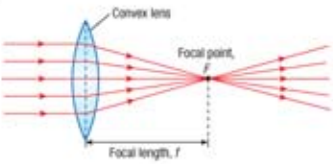
1. (a) Electrolysis is the process of decomposition of a compound in the molten or aqueous state into its constituent elements when electric current flows through it.
(b) Copper(II) ion, Cu^{2+}, hydrogen ion, H^+, sulphate ion, SO_4^{2-}, hydroxide ion, OH^-
(c) (i) At anode: Hydroxide ion
At cathode: Copper(II) ion
(ii) At anode: No ion is discharged
At cathode: Copper(II) ion
(d) Purification of metal

2. (a) (i) Sodium ion, Na^+, hydrogen ion, H^+
(ii) Nitrate ion, NO_3^-, hydroxide ion, OH^-
(b) Electrode P
(c) (i) Hydroxide ion
(ii) Hydrogen ion
(d) Sodium ions and hydrogen ions move to the cathode. The hydrogen ion is selected to be discharged because it is less electropositive compared to the sodium ion.

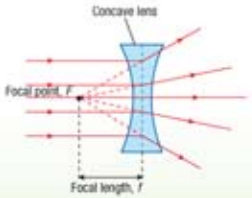
CHAPTER 7 Light and Optics

Summative Practice 7

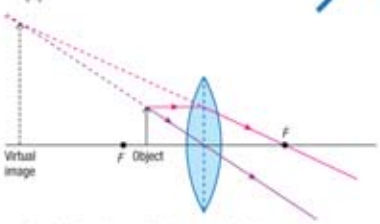
1. (a)



(b)



2. (a)



(b) Virtual, upright, magnified

3. (a) To produce images of different sizes using camera lenses of different focal lengths

CHAPTER 8 Force and Pressure

Summative Practice 8

1. (a) P_1
(b) When air flows through the narrow space between the two cars, the velocity of air flow increases and the pressure, P_1 in the narrow space reduces. According to Bernoulli's principle, when a fluid such as air passes through a narrow space, the velocity of the fluid flow increases and pressure in the space decreases.
(c) Pressure P_0 which is higher compared to P_1 will cause both vehicles to be pushed towards each other until they collide.

CHAPTER 9 Space Technology

Summative Practice 9

1. (a) GPS satellite
(b) For navigational purposes

2. (a)
- GPS satellite is a communication satellite
- Orbital height for a GPS satellite is 20 000 km
- Orbital period for a GPS satellite is 12 hours

(b) Smartphone
(c) Navigational purposes
(any suitable answer)
(d) Google Maps, Waze

Complete answers for teachers
http://buku-teks.com/sc5252

Laboratory Rules and Safety Measures

In this Form 5 Science KSSM textbook, there are some experiments that need to be carried out in the laboratory. Therefore, all students must comply with the rules and safety measures in the laboratory to avoid accidents.

Before entering the laboratory

1. Do not enter the laboratory without the teacher's permission.
2. Do not bring bags or other items into the laboratory without the teacher's permission.

In the laboratory

1. Open all windows and doors.
2. Do not run or play.
3. Do not eat or drink.
4. Do not carry out any experiment or procedure without the teacher's permission.
5. Follow all procedures in the experiment with the teacher's guidance.
6. Take safety measures such as reading all instructions and warning symbols on the labels of reagent bottles before using the chemicals.
7. Take fire safety measures such as keeping yourself, books, clothes, hair and other flammable things away from fire.

Emergencies

1. Know the location of and how to use the fire extinguisher and the first aid kit.
2. If any chemical substance gets into your eyes, wash it off immediately with plenty of running water.
3. If any chemical substance spills onto your skin or clothes, wash it off immediately with plenty of water.
4. If any chemical substance is accidentally swallowed, spit it out immediately and rinse your mouth with plenty of water. Inform the teacher of the accident immediately for medical treatment.
5. If your clothes are on fire, do not panic, roll your body on the floor or wrap your body with a fire blanket to extinguish the fire.
6. Report all accidents to the teacher immediately.

Before leaving the laboratory

1. Turn off or switch off all water, gas and electrical supplies.
2. Clean and tidy all apparatus used.
3. Return all apparatus and chemical substances to their original location.
4. Dispose all experimental waste according to their category.
5. Wash your hands.