Technical Sciences

Grade 12

Teacher's Guide

This book was developed with the participation of the Department of Basic Education of South Africa
and funding by the Sasol Inzalo Foundation

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This book was developed with the participation of the Department of Basic Education (DBE) of South Africa, Magic Moments Consulting & Services and ACP Project Management & Publishing Services; and funded as an ongoing project by Sasol Inzalo Foundation.

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Introduction

OVERVIEW

Dear teacher, welcome to the community of teachers that make a difference by unlocking the potential and arousing love of the Technical Sciences to learners. What a privilege you have to guide the learners to think creatively!

The National Curriculum Statement Grades R – 12 (NCS) stipulates policy on curriculum and assessment in the schooling sector. To improve implementation, the National Curriculum Statement was amended, with the amendments coming into effect in January 2012. A single comprehensive Curriculum and Assessment Policy document was developed for each subject to replace Subject Statements, Learning Programme Guidelines and Subject Assessment Guidelines in Grades R – 12.

This Teacher's Guide is divided into two main parts:

- **Part 1** **Understanding the CAPS Policy Document for Technical Sciences**
- **Part 2** **Solutions to the Activities, Experiments, Informal and Formal Assessment Tasks in the Learner's Book**

PART 1 UNDERSTANDING THE CAPS POLICY DOCUMENT FOR TECHNICAL SCIENCES

The National Curriculum and Assessment Policy Statement for Technical Sciences has four sections:

CAPS for Technical Sciences	
Section 1	Introduction to the curriculum and assessment policy statements for Technical Sciences Grades 10 – 12
Section 2	The aims and purpose of technical sciences
Section 3	Technical Sciences content (Grades 10 – 12)
Section 4	Assessment

This part will assist you in getting to grips with the objectives and requirements laid down for the Technical Sciences at national level, and how to implement the prescribed policy document.

The aims and purpose of Technical Sciences

The main aim of Technical Sciences is to support learners in the three focus areas of technology, namely Mechanical Technology, Electrical Technology and Civil Technology.

Learners will have an NQF Level 4 competence in Technical Sciences.

Learners attending Technical High Schools will be able to integrate scientific knowledge in their subject offerings in Technology in a more informed way. Scientific concepts and skills will also be more accessible to learners that have a technical orientation in schooling. Technical Sciences is an enabling subject that will address the needs of the industry and the technology subjects and promoting the study of technology in schools.

Skills that learners will acquire include classifying, communicating, measuring, designing an investigation, drawing and evaluating conclusions, formulating models, hypothesising, identifying and controlling variables, observing and comparing, interpreting, predicting, problem-solving and reflecting. The main skills will be practical application and observing simulations.

Technical Sciences will prepare learners for further education and training, employment, citizenship, holistic development and socio-economic development. It is envisioned that learners choosing Technical Sciences as a subject in Grades 10 – 12 will have improved access to applied technology courses, vocational career paths and entrepreneurial opportunities. Technical Sciences will also promote skills development in the fields of technology, thus promoting economic growth and social well-being of more citizens in our country.

The six main knowledge areas that Technical Sciences comprises of are:

- Mechanics
- Waves, Sound and Light
- Matter and Materials
- Electricity
- Heat and Thermodynamics
- Chemical Change

Overview of topics in Grade 12

Topic	Content
Mechanics	Newton's laws of motion (Newton's First Law of motion, inertia, mass, Acceleration, Newton's Second Law of motion, Newton's Third Law of motion), Momentum (Impulse and change in momentum), Work energy and Power (Work, Energy, Conservation of mechanical energy, Power, Power and velocity), Elasticity (Deforming force, restoring force, elasticity, perfectly elastic body, elastic limit, stress, strain, Hooke's Law,) Viscosity (effect of temperature on viscosity, motor oil viscosity grades), Hydraulics (Thrust, pressure, practical unit of pressure, fluid pressure, Pascal's Law, hydraulic lift) **(46 hours)**
Matter and materials	Electronic Properties of Matter (Semiconductor, intrinsic semiconductor, doping, n-type semiconductor, p- type semiconductor, p-n-junction diode) **(4 hours)** Organic chemistry (Organic molecules, molecular and structural formulae, functional group, homologous series, saturated hydrocarbons, unsaturated hydrocarbons, isomers, IUPAC naming and formulae, physical properties of organic compounds, reactions of organic compounds, plastics and polymers) **(12 hours)**

Topic	Content
Waves and Sound	Light (Reflection of light, Refraction, Critical angle, total internal reflection, Dispersion, lenses) Electromagnetic radiation (Nature of Electromagnetic radiation, properties of electromagnetic radiation, electromagnetic spectrum, uses of electromagnetic radiation, photons, energy of a photon) **(12 hours)**
Electricity and Magnetism	Electrostatics (Capacitor, capacitance, factors affecting capacitance) Electric circuits (Power, heating effect of electric current) Electromagnetism (Magnetic effect of a current-carrying conductor, electromagnetic induction Faraday's Law, magnetic flux, magnetic flux density, Lenz's Law, transformer, generator, motor) **(28 hours)**
Heat and Thermodynamics	Not applicable for Grade 12
Chemical Change	Electrochemical cells (Electrolytic cells, galvanic cells, components of galvanic cells, half reactions, net reaction, standard conditions, ionic movement, standard cell notation, emf of a cell) Alternate Energies (Biodiesel, fuel cells, photovoltaic cells) **(10 hours)**

Overview of practical work

Term	Prescribed Practical Activities Formal Assessment	Recommended Practical Activities Informal Assessment
Term 1	**Experiments (formal):** Determine the relationship between acceleration and force for a constant mass.	**Experiment:** Show that the action-reaction pairs cancel each other. **Experiment:** To determine if momentum is conserved during a collision **Experiment:** Determine the power output of a learner.
Term 2	**Experiment (formal):** Determine the path of a ray of light through a glass slab for different angles of incidence	**Experiment:** Determine the position of an image in a flat mirror

Term	Prescribed Practical Activities Formal Assessment	Recommended Practical Activities Informal Assessment
Term 3	**Experiment (formal):** To determine the electrode potential of a Cu-Zn electrochemical cell.	**Experiment:** Determine the power dissipated in bulbs connected either in series or parallel or both in series and both in parallel **Experiment:** Determine the current rating of a fuse. **Experiment:** Determine the effect of the change in magnetic field or magnetic flux in a coil. **Experiment:** Study the characteristics of p-n junction diode.

Weighting of topics

TOPICS	%
Mechanics	47
Waves and sound	13
Electricity and magnetism	18
Matter and material	13
Chemical change	10
Heat and thermodynamics	0

Overview of formal and recommended informal experiment

PROGRAMME OF ASSESSMENT FOR GRADES 10, 11 and 12						
ASSESSMENT TASKS (25%) + PAT (25%)						END OF YEAR ASSESSMENT (50%)
Term 1		**Term 2**		**Term 3**		**Term 4**
Type	**Mark**	**Type**	**Mark**	**Type**	**Mark**	**Final Examination** (2 × 150 marks giving a total of 300 marks for Papers 1 and 2)
Experiment (SBA)	20	Experiment (SBA)	30	Experiments (PAT)	100	
Control Test	20	Mid-Year Examination (SBA) Project (PAT)	40 50	Trial Examination (Grade 12) Control Test (Grades 10 and 11) (SBA)	40	
Total: 40 marks		**Total: 120 marks**		**Total: 140 marks**		**Total: 300**
Total = 600 marks						
FINAL MARK = 25% (ASSESSMENT TASKS), 25 % (PAT) + 50% (FINAL EXAM) = 100%						

NB: PAT will consist of two experiments (one in Physics and one in Chemistry) + One Project. These will be set annually by the DBE.

PART 2 SOLUTIONS TO THE ACTIVITIES, EXPERIMENTS, INFORMAL AND FORMAL ASSESSMENT TASKS IN THE LEARNER'S BOOK

Each chapter in the Learner's Book addresses prescribed content, concepts and skills.

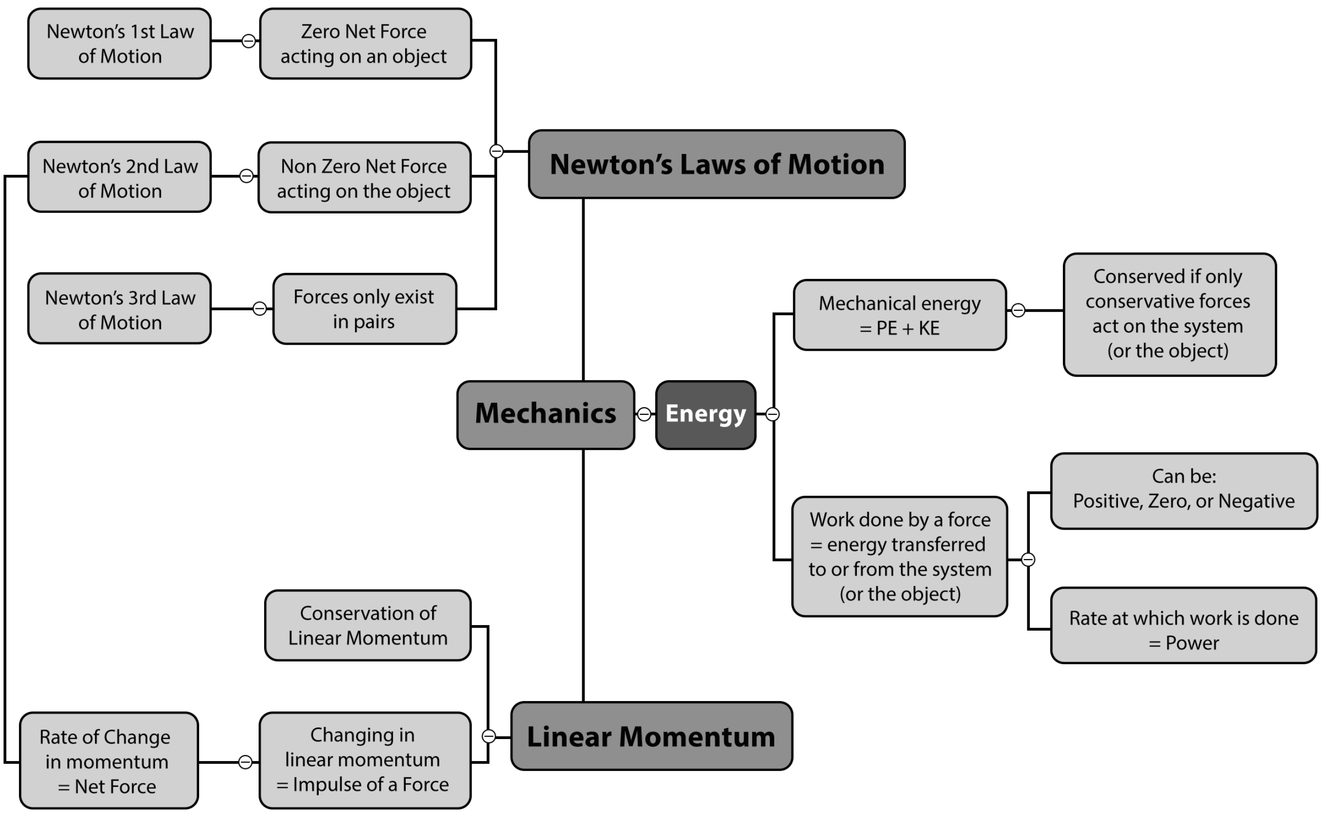
The range of activities includes practical activities, experiments, and informal and formal assessment tasks.

1 Mechanics: Newton's laws and momentum

CHAPTER OVERVIEW

Mechanics, in a nutshell, is the study of the relationships between energy, motion and force. It is answer key to how universe works. For example, why does a car skid on a wetroad? Mechanics is a large field and its study is essential to the understanding of physics, which is why these chapters appear first. Mechanics can be divided into sub-disciplines by combining and recombining its different aspects. Three of these are given special names. Motion is the action of changing location or position. The study of motion without regard to the forces or energies that may be involved is called kinematics. It is the simplest branch of mechanics. The branch of mechanics that deals with both motion and forces together is called dynamics and the study of forces in the absence of changes in motion or energy is called statics

Concept map



Suggested answers

Activity 1.1 Newton's first law of motion *(LB p. 7)*

1. B

2.
   2.1. Inertia is the tendency of an object to resist the change in its state of motion.
   2.2 Mass is measure of the object's inertia.
   2.3 Weight is the gravitational force which the Earth exert on an object near the Earth's surface.
   2.4 An object moving at constant speed on a straight line is said to be in dynamic equilibrium.

3. Newton's first law of motion states that an object will remain at rest, or continue moving at a constant speed on a straight line, unless acted upon by non-zero net force.

4. 0 N. According to Newton's first law of motion an object will continue moving at a constant speed on a straight if the net force acting on it is zero.

5. The Bull Moose is more massive than a man, and this means it has more inertia than the man. Making a zigzag run will mean a bull moose will not make zigzag turns as fast as the man. Inertia of an object is its tendency to retain its state of motion. And so the Bull Moose's inertia will resists the change in its state of motion.

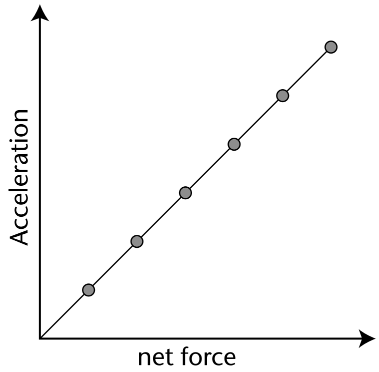
6.
   6.1 Not in equilibrium. At the maximum height the parachute stops momentarily before falling down. However, the net force acting on the object equal to the weight of the parachute, which is not zero.
   6.2 Not in equilibrium. Because here even though the speed of a car remains constant, when moving around a curve its direction changes, and an object changing direction is accelerating.
   6.3 In Equilibrium. Here the object's speed and direction do not change.
   6.4 Not in equilibrium. Here the stone is accelerating vertically downwards, and so the net force acting on the stone is not zero.

7. The skateboard will slow down or stop, but a person riding a skate board will continue moving on a straight with the same speed as the initial speed of the skateboard. The man's inertia will resist the change in velocity.

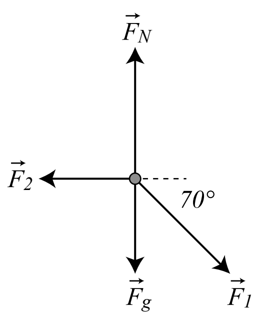
8. During a rear end collision the car's speed increases in the forward direction. The inertia passengers inside the car will resists their bodies from changing the speed. Hence, the seat will push the passengers bodies forward causing the neck to remain in its initial position. This may cause whip-lash injuries to the passenger's neck. Headrests helps prevent whiplash injuries in that they prevent the neck from lunging backwards during the rear-end collision.

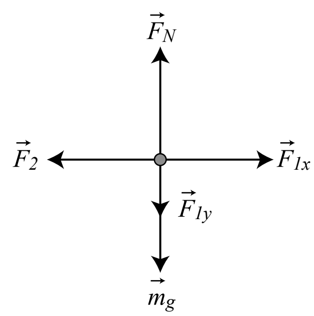
Activity 1.2 Newton's second law of motion

(LB p. 16)

1. The acceleration of an object is the rate at which the object's velocity changes.
2. Newton's second law of motion states that when a net force acts on an object of mass m, the object will accelerate in the direction of the net force. The magnitude of the acceleration will be directly proportional to the net force, and inversely proportional to the object's mass.
3. 2F. The acceleration of an object is directly proportional to the net force acting on the object.
4. $\frac{1}{2}a$ The acceleration of an object is inversely proportional to the mass of an object.
5. 

6. The free body diagram of the forces acting on the block can be drawn in two equivalent methods: firstly by drawing all the forces acting on the block as they are, secondly with the 2D force resolved into its horizontal and vertical components.





Because we want to calculate the horizontal acceleration, it means we should consider only the forces acting in the horizontal direction and calculate their net force from which we will get the acceleration. Take the direction to the left as negative.

$$\vec{F}_{net} = m\vec{a}$$

$$\vec{F}_2 + \vec{F}_{1x} = m\vec{a}_x$$

$$-33 + 59\cos 70^{\circ} = 7\vec{a}$$

$$-12,82 = 7\vec{a}$$

$$\therefore\ \vec{a} = -1,83\ \text{m} \cdot \text{s}^{-2}$$

The acceleration of the block is 1,83 m · s^{-2} to the left.

7. Let the direction to the east be positive.

When both the forces point due east, the object's acceleration is 0,5 m·s^{-2}

$$\vec{F}_{net} = m\vec{a}$$
$$F_A + F_B = (8)(0,5)$$
$$F_A + F_B = 4$$
$$\therefore\ F_A = 4 - F_B \ \ldots\ \ldots(1)$$

However, when $\vec{F}_A$ points due east and $\vec{F}_B$ due west, the object's acceleration is 0,4 m·s^{-2}.

$$F_A - F_B = m\vec{a}$$
$$(4 - F_B) - F_B = (8)(0,4)$$
$$4 - 2F_B = 3,2$$
$$-2F_B = -0,8$$
$$\therefore\ F_B = 0,4\ \text{N}$$

Substituting this into (1) gives:

$$F_A = 4 - 0,4$$
$$F_A = 3,6\ \text{N}$$

8. The acceleration of the car and its riders is:

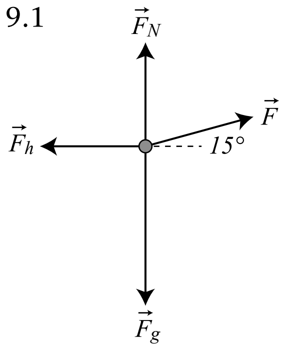
$$\vec{a} = \frac{\vec{v}_f - v_i}{\Delta t}$$
$$\vec{a} = \frac{45 - 0}{9} = 5\ \text{m} \cdot \text{s}^{-2}$$

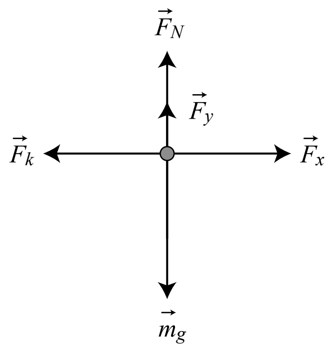
The net force acting on the car and it riders will be:

$$\vec{F}_{net} = m\vec{a}$$
$$\vec{F}_{net} = (5,5 \times 10^3)(5)$$
$$\therefore\ \vec{F}_{net} = 2,75 \times 10^4\ \text{N}$$

9. We are told that the block slides across a horizontal, rough surface at a constant speed.

9.1





9.2 The net force acting on the block is 0 N. Because the block is not accelerating.

9.3 Consider the forces acting in the vertical direction. Let the direction up be positive.

$$\begin{aligned} \vec{F}_{net} &= m\vec{a} \\ \vec{F}_N + \vec{F}_y + mg &= 0 \\ \vec{F}_N + 20\sin 15° + (5)(9,8) &= 0 \\ \vec{F}_N + 5,18 - 49 &= 0 \\ \therefore\ \vec{F}_N &= 43,82 \text{ N} \end{aligned}$$

9.4 Consider the forces acting along the horizontal direction. Let the direction to the right be positive.

$$\begin{aligned} \vec{F}_{net} &= m\vec{a} \\ \vec{F}_k + \vec{F}_x &= 0 \\ \mu_k F_N + F\cos 15° &= 0 \\ \mu_k(43,82) + 20\cos 15° &= 0 \\ \mu_k(43,82) &= -19,32 \\ \therefore\ \mu_k &= 0,44 \end{aligned}$$

9.5 Increase. This will mean that the vertical component of the applied force will be nullified, thus increasing the magnitude of the normal acting on the block which will be the same magnitude as the weight of the block.

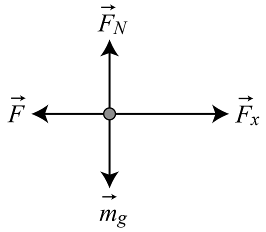
Activity 1.3 Newton's third law of motion *(LB p. 20)*

1. When object A exerts a force on object B, object B simultaneously exerts an oppositely directed force of equal magnitude on object A.
2. Action-reaction pairs:
   2.1 Action force is the force exerted by the gun on the bullet. Reaction force is the recoil force exerted by the bullet on the gun.
   2.2 No action-reaction forces. As the only force acting on the apple as it falls is due to the apple's weight.
   2.3 The action force is the book's weight which it exerts on the table, while the reaction force is the normal force exerted by the table on the book.
   2.4 The action force is the weight of the tennis ball which it exerts on the floor, while the reaction force is the force exerted by the floor on the tennis ball.
3.
   3.1 The action force is the force exerted by the cannon on the cannonball, while the reaction force is the force exerted by the cannon ball on the cannon.
   3.2 They are equal. According to Newton's 3rd law of motion, when object A exerts a force on object B, object B simultaneously exerts an oppositely directed force of equal magnitude on object A.

3.3 The net force acting on the cannon and cannon ball is the same. But the cannon is more massive than the cannonball. So according to Newton's second law of motion, the acceleration of an object is inversely proportional to the mass of an object. Therefore the cannon's acceleration will be less than the cannonball's acceleration. Hence the final velocity of the cannon immediately after the cannon ball is fired will be less than that of a cannon-ball.

Activity 1.4 Applications of Newton's laws of motion *(LB p. 24)*

1.1 Let the force exerted by the 5 kg block on the 7 kg block be $\vec{F}$ and the applied force be $\vec{F}_x$:



1.2 Let the direction to the right be positive For the 7 kg block:

$$\vec{F}_{\text{net}} = m\vec{a}$$

$$\vec{F}_{\partial} + \vec{F} = m\vec{a}$$

$$20 - F = 7a \quad \ldots \quad \ldots(1)$$

For the 5 kg block (it is advisable to draw the free-body diagram for this block as well):

$$\vec{F}_{\text{net}} = m\vec{a}$$

$$\vec{F} = m\vec{a}$$

$$F = 5a \quad \ldots \quad \ldots(2)$$

Substitute (2) into (1) gives:

$$20 - 5a = 7a$$

$$20 = 12a$$

$$\therefore\ a = 1{,}67\ \text{m} \cdot \text{s}^{-2}$$

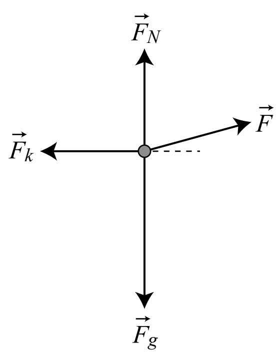
1.3 Substituting the value of the acceleration into (2) gives:

$$F = 5a$$

$$F = (5)(1{,}67)$$

$$F = 8{,}33\ \text{N}$$

2. For the 5 kg block, the free body diagram is as follows:



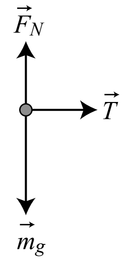
$$\vec{F}_{\text{net}} = m\vec{a}$$

$$\vec{F}_x + \vec{T} = m\vec{a}$$

$$50\cos 20° - T = (5)(a)$$

$$46{,}984 - T = 5\vec{a} \quad \ldots \quad \ldots(1)$$

For the 7 kg block:



$\vec{F}_{\text{net}} = m\vec{a}$

$T = 7\vec{a} \quad \ldots \quad \ldots(2)$

Substitute (2) into (1):

$46{,}984 - 7a = 5\vec{a}$

$46{,}984 = 12\vec{a}$

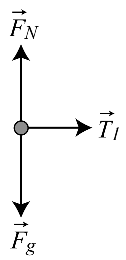
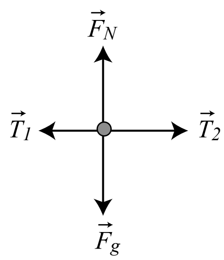
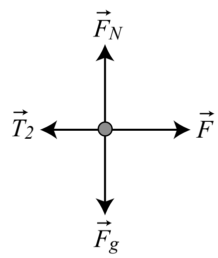
$\therefore \vec{a} = 3{,}915 \text{ m} \cdot \text{s}^{-2}$

Substituting the acceleration into (2) gives:

$T = 7(3{,}915)$

$T = 27{,}405 \text{ N}$

3.1 The free body diagram of the forces acting on each block are:

For the 3 kg block:	For the 5 kg block:	For the 7 kg block:
		

3.2. Applying Newton's second law of motion in each block:

3 kg block:

$\vec{F}_{net} = m\vec{a}$

$T_1 = 3a \quad \ldots \quad \ldots(2)$

5 kg block:

$T_2 - T_1 = 5a$

$T_2 - 3a = 5a$

$T_2 = 8a$

7 kg block:

$F - T_2 = 7a$

$50 - 8a = 7a$

$50 = 15a$

$\therefore a = 3{,}33 \text{ m} \cdot \text{s}^{-2}$

3.3. Substituting the acceleration into (1) and (2) gives:

$$T_1 = 3(3,33)$$
$$T_1 = 1 \text{ N}$$
$$T_2 = 8(3,33)$$
$$T_2 = 26,67 \text{ N}$$

Activity 1.5 Linear momentum

(LB p. 25)

1. Momentum of an object is defined as a product of an object's mass and velocity.
2. If the heavy truck is moving slower than person on a skateboard, they can have the same momentum. Or if the person in a skateboard is moving faster than the heavy truck.
3.

3.1 Let's first convert the speed of a car to its correct SI units:

$$100 \text{ km} \cdot \text{h}^{-1} = 100 \frac{\text{km}}{1 \text{ h}} \times \frac{1\,000 \text{ m}}{1 \text{ km}} \times \frac{1 \text{ h}}{3\,600 \text{ s}} = 27{,}78 \text{ m} \cdot \text{s}^{-1}$$
$$p = mv$$
$$p = (725)(27,78)$$
$$p = 20\ 138,88 \text{ kg} \cdot \text{m} \cdot \text{s}^{-1}$$

3.2 $p = mv$

$$20\ 138,88 = 2\ 175v$$
$$\therefore\ v = 9,26 \text{ m} \cdot \text{s}^{-1}$$

4. Momentum is directly proportional to the speed of an object. Doubling the speed of an object while keeping it mass constant doubles the object's momentum.

$$p_{\text{new}} = mv$$
$$p_{\text{new}} = m(2v)$$
$$p_{\text{new}} = 2mv$$
$$p_{\text{new}} = 2p$$

5. The momentum of 3m object is the same as the momentum of the object of mass m. The speed of the mass m object is:

$$v = \frac{p}{m}$$
$$p_2 = p = mv_2$$
$$p = (3m)(v_2)$$
$$v_2 = \frac{p}{3m} = \frac{1}{3}v$$

Therefore, the object of mass 3m must be travelling at the third of the speed of the mass m object for the two objects to have the same momentum.

Activity 1.6 Impulse and change in momentum *(LB p. 29)*

1. Impulse of a force is the product of the force acting on an object and the time the force acts on the object.
2. The average net force acting on the object is the rate at which the object's momentum changes.
3. Let's convert the mass of the dart into its SI units:

   $$m = 100 \text{ g} \times \frac{1 \text{ kg}}{1\,000 \text{ g}} = 0,1 \text{ kg}$$

   Let the direction towards the dartboard be positive. The average net force required to stop the dart is:

   $$\vec{F}\Delta t = m(\vec{v}_f - \vec{v}_i)$$
   $$F(0,04) = 0,1(0-6)$$
   $$F = -\frac{0,6}{0,04} = -15 \text{ N}$$

   Therefore, the average net force required to stop the dart is 15 N away from the dartboard.

4. The object change in momentum is the same as the object's change in momentum.

   4.1 $\vec{F}\Delta t = \Delta\vec{p}$

   $(6)(10) = \Delta\vec{p}$

   $\Delta\vec{p} = 60 \text{ kg} \cdot \text{m} \cdot \text{s}^{-1}$

   4.2 $\Delta\vec{p} = m(\vec{v}_f - \vec{v}_i)$

   $60 = 3(\vec{v}_f - 0)$

   $60 = 3\vec{v}_f$

   $\vec{v}_f = 20 \text{ m} \cdot \text{s}^{-1}$

5. The velocity of the tennis ball can be calculated from the equation of motion. Let the direction towards the floor be positive:

   5.1 $v_f^2 = v_i^2 + 2a\Delta x$

   $v_f^2 = (4) + 2(9,8)(10)$

   $v_f^2 = 196$

   $\therefore\ v_f = 14 \text{ m} \cdot \text{s}^{-1}$

   5.2 $\vec{F}_{net}\Delta t = m(\vec{v}_f - \vec{v}_i)$

   $\vec{F}_{net}(0,1) = (0,01)(-12 - 14)$

   $\vec{F}_{net}(0,1) = -0,16$

   $\vec{F}_{net} = -1,6 \text{ N}$

Therefore the average net force exerted by the floor on the tennis ball is 1,6 N away from the floor.

6.

6.1 Airbags increase the taken by the passenger in car to come to rest after the car has had a collision. Because the person's mass doesn't decrease during the impact, the change in momentum remains the same despite the contact between the passenger and the car increasing. The average net force exerted by the airbags is decreased by increasing the time of contact, while keeping the change in momentum the same. Reducing the force means decreasing the chances of serious injuries.

6.2 When cars nowadays crash, they crumple. Crumpling, like the airbags increases the time of contact between the car and the wall it crushes against bringing the car to rest. As already mentioned, increasing the time of contact between objects while keeping their changing in momentum the same decreases the average force the object exert on one another.

7. Let the direction towards the wall be positive:

7.1
$$\vec{F}_{\text{net}}\Delta t = m(\vec{v}_{\text{f}} - \vec{v}_{\text{i}})$$
$$\vec{F}_{\text{net}}\Delta t = 1{,}2 \times 10^3(-2 - 12)$$
$$\vec{F}_{\text{net}}\Delta t = -16\ 800 \text{ N} \cdot \text{s}$$

Therefore the impulse on the car is 16 800 N·s away from the wall.

7.2
$$\vec{F}_{\text{net}}\Delta t = -16\ 800$$
$$\vec{F}_{\text{net}}(0{,}1) = -16\ 800$$
$$\vec{F}_{\text{net}} = -168\ 000$$
$$\therefore \vec{F}_{\text{net}} = -168\ 000 \text{ N away from the wall}$$

7.3 Decrease. When the car doesn't bounce off the wall the change in momentum decreases. For the same time interval, the average force exerted by the wall on the car is directly proportional to the change in momentum of the car. Hence the average force exerted on car will decrease if the car didn't bounce off the wall.

Activity 1.7 Conservation of linear momentum *(LB p. 36)*

1. The principle of conservation of linear momentum states that, the total linear momentum of an isolated system remains conserved in magnitude and direction.
2. In an elastic collision both the momentum and the kinetic energy of the system are conserved, whereas in an inelastic collision only the momentum of the system is conserved.
3. A system on which the resultant/net external force is zero.
4. Conservation in science means that the magnitude of a physical quantity before and after a system undergoes any physical change (or process) remains the same.

5. Let the direction to the west be positive. Before firing the missile, both the cannon and the missile are stationary. So the initial moment of the cannon-missile system is zero.

$\sum\vec{p}_{\mathrm{i}} = \sum\vec{p}_{\mathrm{f}}$

$0 = m_1\vec{v}_{\mathrm{f1}} + m_2\vec{v}_{\mathrm{f2}}$

$0 = (12)(500) + (1\ 500)\vec{v}_{\mathrm{f2}}$

$-6\ 000 = 1\ 500\vec{v}_{\mathrm{f2}}$

$\therefore\ \vec{v}_{\mathrm{f2}} = -4\ \mathrm{m \cdot s^{-1}}$

$\therefore\ \vec{v}_{\mathrm{f2}} = 4\ \mathrm{m \cdot s^{-1}}$ due east

6. Let the initial direction of the 0,5 kg ball be positive.

6.1. $\sum\vec{p}_{\mathrm{i}} = \sum\vec{p}_{\mathrm{f}}$

$m_1\vec{v}_{\mathrm{i1}} + m_2\vec{v}_{\mathrm{i2}} = m_1\vec{v}_{\mathrm{f1}} + m_2\vec{v}_{\mathrm{f2}}$

$(0,5)(6) + (1)(-12) = (0,5)(-14) + (1)\left(\vec{v}_{\mathrm{f2}}\right)$

$-9 = -7 + \vec{v}_{\mathrm{f2}}$

$\therefore\ \vec{v}_{\mathrm{f2}} = -2\ \mathrm{m \cdot s^{-1}}$

$\therefore\ \vec{v}_{\mathrm{f2}} = 2\ \mathrm{m \cdot s^{-1}}$ in the direction opposite the initial direction of the 0,5 kg ball

6.2. We have to calculate and compare the initial and final kinetic energy.

$\sum E_{\mathrm{Ki}} = \frac{1}{2}m_1v_{\mathrm{i1}}^2 + \frac{1}{2}m_2v_{\mathrm{i2}}^2$

$\sum E_{\mathrm{Ki}} = \frac{1}{2}(0,5)(6)^2 + \frac{1}{2}(1)(12)^2$

$\sum E_{\mathrm{Ki}} = 9 + 72 = 81\ \mathrm{J}$

$\sum E_{\mathrm{Kf}} = \frac{1}{2}m_1v_{\mathrm{f1}}^2 + \frac{1}{2}m_2v_{\mathrm{f2}}^2$

$\sum E_{\mathrm{Kf}} = \frac{1}{2}(0,5)(14)^2 + \frac{1}{2}(1)(2)^2$

$\sum E_{\mathrm{Kf}} = 49 + 2 = 51\ \mathrm{J}$

The kinetic energy of the system is not conserved. Therefore this is an inelastic collision.

7.

7.1. Zero. Because both the projectile and the launcher were initially at rest.

7.2. Let the direction projectile velocity be positive.

$\sum\vec{p}_{\mathrm{i}} = \sum\vec{p}_{\mathrm{f}}$

$0 = m\vec{v}_{\mathrm{f1}} + m\vec{v}_{\mathrm{f2}}$

$0 = (40)(800) + (200)\vec{v}_{\mathrm{f2}}$

$-32\ 000 = 200\vec{v}_{\mathrm{f2}}$

$\therefore\ \vec{v}_{\mathrm{f2}} = -160\ \mathrm{m \cdot s^{-1}}$

$\therefore\ \vec{v}_{\mathrm{f2}} = 160\ \mathrm{m \cdot s^{-1}}$ opposite the direction of the projectile

8.

8.1 Initially the boy has been standing still

$$\sum\vec{p}_{\mathrm{i}} = \sum\vec{p}_{\mathrm{f}}$$
$$m_1\vec{v}_{\mathrm{i1}} + m_2\vec{v}_{\mathrm{i2}} = (m_1 + m_2)v_{\mathrm{f}}$$
$$(87)(\vec{v}_{\mathrm{i1}}) + (22)(0) = (87 + 22)(24)$$
$$87\vec{v}_{\mathrm{i1}} = 2\ 616$$
$$\vec{v}_{\mathrm{i1}} = 30{,}07\ \mathrm{m\cdot s^{-1}}$$

8.2
$$\sum E_{\mathrm{Ki}} = \frac{1}{2}m_1 v_{\mathrm{i1}}^2 + \frac{1}{2}m_2 v_{\mathrm{i2}}^2$$
$$\sum E_{\mathrm{Ki}} = \frac{1}{2}(87)(30{,}07)^2 + \frac{1}{2}(22)(0)^2$$
$$\sum E_{\mathrm{Ki}} = 39\ 330\ \mathrm{J}$$
$$\sum E_{\mathrm{Kf}} = \frac{1}{2}(m_1 + m_2)v_{\mathrm{f1}}^2$$
$$\sum E_{\mathrm{Kf}} = \frac{1}{2}(87 + 22)(24)^2 = 31\ 392\ \mathrm{J}$$

This is an example of an inelastic collision.

9. We are told that the collision is elastic.

9.1 Both the momentum and the kinetic energy of the system are conserved in an elastic collision.

9.2
$$\Sigma\vec{\mathrm{p}}_{\mathrm{i}} = \Sigma\vec{\mathrm{p}}_{\mathrm{f}}$$
$$\mathrm{m_1\vec{v}_{i1} + m_2\vec{v}_{i2} = m_1\vec{v}_{f1} + m_2\vec{v}_{f2}}$$
$$(10)(5) + (5)(3) = (10)(\vec{\mathrm{v}}_{\mathrm{f1}}) + (5)(\vec{\mathrm{v}}_{\mathrm{f2}})$$
$$65 = (10)(\vec{\mathrm{v}}_{\mathrm{f1}}) + (5)(\vec{\mathrm{v}}_{\mathrm{f2}})$$
$$13 = 2(\vec{\mathrm{v}}_{\mathrm{f1}}) + \vec{\mathrm{v}}_{\mathrm{f2}}$$
$$\therefore\ \vec{\mathrm{v}}_{\mathrm{f2}} = 13 - 2\vec{\mathrm{v}}_{\mathrm{f1}}$$

$$\Sigma\mathrm{E_{Ki}} = \Sigma\mathrm{E_{Kf}}$$
$$\frac{1}{2}\mathrm{m_1v_{i1}^2} + \frac{1}{2}\mathrm{m_2v_{i2}^2} = \frac{1}{2}\mathrm{m_1v_{f1}^2} + \frac{1}{2}\mathrm{m_2v_{f2}^2}$$
$$\frac{1}{2}(10)(5)^2 + \frac{1}{2}(5)(3)^2 = \frac{1}{2}(10)(\mathrm{v_{f1}^2}) + \frac{1}{2}(5)(\mathrm{v_{f2}^2})$$
$$147{,}5 = 5\mathrm{v_{f1}^2} + 2.5\mathrm{v_{f2}^2}$$
$$59 = 2\mathrm{v_{f1}^2} + \mathrm{v_{f2}^2}$$
$$59 = 2\mathrm{v_{f1}^2} + (13 - 2\vec{\mathrm{v}}_{\mathrm{f1}})^2$$
$$59 = 2\vec{\mathrm{v}}_{\mathrm{f1}} + 169 - 52\vec{\mathrm{v}}_{\mathrm{f1}} + 4\vec{\mathrm{v}}_{\mathrm{f1}}$$
$$0 = 6\vec{\mathrm{v}}_{\mathrm{f1}}^2 - 52\vec{\mathrm{v}}_{\mathrm{f1}} + 110$$

Using the quadratic equation we get that:

$$\vec{\mathrm{v}}_{\mathrm{f1}} = \frac{-\mathrm{b} \pm \sqrt{\mathrm{b}^2 - 4\mathrm{ac}}}{2\mathrm{a}}$$
$$\vec{\mathrm{v}}_{\mathrm{f1}} = 5\ \mathrm{m\cdot s^{-1}}\ \text{or}\ \vec{\mathrm{v}}_{\mathrm{f1}} = 3{,}66\ \mathrm{m\cdot s^{-1}}$$
$$\therefore\ \vec{\mathrm{v}}_{\mathrm{f1}} = 3{,}66\ \mathrm{m\cdot s^{-1}}$$
$$\therefore\ \vec{\mathrm{v}}_{\mathrm{f2}} = 13 - 2(3{,}66)$$
$$\therefore\ \vec{\mathrm{v}}_{\mathrm{f2}} = 5{,}68\ \mathrm{m\cdot s^{-1}}$$

10. After the collision the bullet get stuck in the block.

10.1 $\Sigma\vec{p}_i = \Sigma\vec{p}_f$

$m_1\vec{v}_{i1} + m_2\vec{v}_{i2} = (m_1 + m_2)\vec{v}_f$

$\left(\frac{10}{1000}\right)(300) + (1,99)(0) = \left(\frac{10}{1000} + 1,99\right)\vec{v}_f$

$3 = 2\vec{v}_f$

$\therefore \vec{v}_f = 1,5 \text{ m}\cdot\text{s}^{-1}$

10.2 $\Sigma E_{Ki} = \frac{1}{2}m_1 v_{i1}^2 + \frac{1}{2}m_2 v_{i2}^2 \Sigma E_{Kf}$

$\Sigma E_{Ki} = \frac{1}{2}\left(\frac{10}{1000}\right)(300)^2 + \frac{1}{2}(1,999)(0)^2$

$\Sigma E_{Ki} = 450 \text{ J}$

$\Sigma E_{Kf} = \frac{1}{2}m_1 v_{f1}^2 + \frac{1}{2}m_2 v_{f2}^2$

$\Sigma E_{Kf} = \frac{1}{2}\left(\frac{10}{1000} + 1,99\right)(1,5)^2$

$\Sigma E_{Kf} = 2,25 \text{ J}$

Therefore this is an inelastic collision.

Activity 1.8 Work done *(LB p. 42)*

1. Work is defined as a product of a force to an object and the displacement parallel to the force applied.
2. Work is not done on an object if:
   2.1 When the force acting on the object doesn't displace the object.
   2.2 The force acting on an object is perpendicular to the object's displacement.
3. $W = F\Delta x \cos\theta$

   $W = (20)(4)(\cos 25°)$

   $W = 72,50 \text{ J}$
4. Each worker is exerting to the bags a force equal to the weight of the total mass he is lifting. For worker x, the displacement is 0,8 m. from the ground the second shelf, where each shelf is 0,4 m high.

   $W_x = F_x \Delta x_1$

   $W_x = (3 \times 5 \times 9,8)(2 \times 0,4)$

   $W_x = 117,6 \text{ J}$

   $W_y = F_y \Delta x_2$

   $W_y = (5 \times 9,8)(5 \times 0,4)$

   $W_y = 98 \text{ J}$

   Therefore worker x has done more work than worker y.

5.

5.1 $W = F\Delta x \cos\theta$

$W = (10)(6)\cos 0°$

$W = 60\ J$

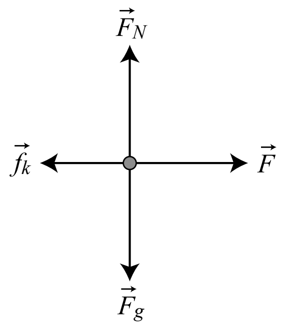
5.2 $W_f = F\Delta x \cos\theta$

$W_f = (4)(6)\cos 180°$

$W_f = -24\ J$

6.

6.1 Free body diagram:



6.2 $\vec{F}_{net} = m\vec{a}$

$\vec{F} + \vec{f}_k = m\vec{a}$

$F - \mu_k mg = m\vec{a}$

$F - (0,22)(10)(9,8) = (10)(2)$

$F - 21,56 = 20$

$\therefore F = 41,56\ N$

6.3 $W = F\Delta x \cos\theta$

$W = (41,56)(5)(\cos 0°)$

$W = 207,8\ J$

6.4 $W_f = F\Delta x \cos\theta$

$W_f = (21,56)(5)\cos 180°$

$W_f = -107,8\ J$

6.5 $W_f = F\Delta x \cos\theta$

$W_f = (mg)(\Delta x)\cos 90°$

$W_f = 0\ J$

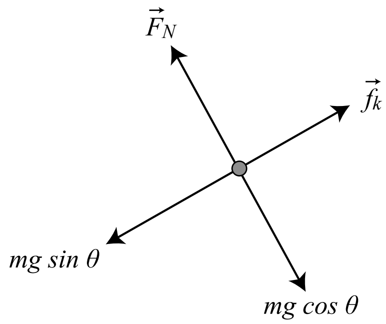
6.6 $W_f = F\Delta x \cos\theta$

$W_f = (mg)(\Delta x)\cos 90°$

$W_f = 0\ J$

7. Normal force

7.1



7.2
$$\begin{aligned} f_k &= \mu_k F_N \\ f_k &= (0,22)(mg\cos\theta) \\ f_k &= 0,22(10)(9,8)\cos 20° \\ f_k &= 20,26\ \text{N} \end{aligned}$$

7.3
$$\begin{aligned} W_f &= F\Delta x\cos\theta \\ W_f &= (20,26)(4)(\cos 180°) \\ W_f &= 81,04\ \text{J} \end{aligned}$$

7.4
$$\begin{aligned} W_g &= F\Delta x\cos\theta \\ W_g &= (mg)(\sin 20°)\Delta x\cos 0° \\ W_g &= (10)(9,8)(\sin 20°)\cos 0° \\ W_g &= 33,52\ \text{J} \end{aligned}$$

7.5 0 J. The normal force acts perpendicular to the block's displacement.

Activity 1.9 Mechanical energy conservation *(LB p. 46)*

1. Definitions
   1.1. Kinetic energy is the energy which a body possesses by virtue of being in motion.
   1.2. Gravitational potential energy is the energy an object has because of its position in the gravitational field.
   1.3. Mechanical energy is the sum of the gravitational potential energy and the kinetic energy of an object at a given point.

2. The Principle of conservation of mechanical energy states that the total energy of an isolated system remains constant.

3. Firstly we must convert the mass of the ball to kg.

3.1.
$$\begin{aligned} E_M &= mgh + \tfrac{1}{2}mv^2 \\ E_M &= 70 + \tfrac{1}{2}\left(\tfrac{240}{1\,000}\right)(20)^2 \\ E_M &= 118\ \text{J} \end{aligned}$$

3.2. When the ball hits the ground its height will be zero, and its gravitational potential energy will also be zero.

$$E_M = mgh + \frac{1}{2}mv^2$$
$$118 = 0 + \frac{1}{2}(0,24)(v^2)$$
$$118 = 0,12v^2$$
$$v^2 = 983,33$$
$$v_f = 31,36 \text{ m} \cdot \text{s}^{-1}$$

The ball will hit the ground with the maximum speed of $v_f = 31,36 \text{ m} \cdot \text{s}^{-1}$.

4.

4.1. $E_{MA} = E_{MC}$

$$\left(mgh + \frac{1}{2}mv^2\right)_A = \left(mgh + \frac{1}{2}mv^2\right)_B$$
$$(m)(9,8)(10) + \frac{1}{2}m(5)^2 = 0 + \frac{1}{2}m(v^2)$$
$$110,5m = \frac{1}{2}mv^2$$
$$221 = v^2$$
$v = 14,87 \text{ m} \cdot \text{s}^{-1}$ at B.

4.2. $E_{MA} = E_{MC}$

$$\left(mgh + \frac{1}{2}mv^2\right)_A = \left(mgh + \frac{1}{2}mv^2\right)_B$$
$$(m)(9,8)(10) + \frac{1}{2}m(5)^2 = (m)(9,8)(8) + \frac{1}{2}m(v^2)$$
$$110,5m = 78,4m + \frac{1}{2}mv^2$$
$$32,1m = \frac{1}{2}mv^2$$
$$64,2 = v^2$$
$v = 8,01 \text{ m} \cdot \text{s}^{-1}$ at C.

4.3. The maximum height that the car will reach is where it will stop and change the direction and is calculated as follows:

$$E_M = mgh + \frac{1}{2}mv^2$$
$$110,5m = (m)(9,8)(h) + 0$$
$$110,5 = 9,8h$$
$$h = 11,28 \text{ m}$$

Therefore the car will not reach the point D.

5. First convert the mass of the basketball to its SI units. Assume the basketball started falling from rest.

5.1. $\left(mgh + \frac{1}{2}mv^2\right)_{\text{top}} = \left(mgh + \frac{1}{2}mv^2\right)_{\text{bottom}}$

$$(0,625)(9,8)(3,05) + 0 = 0 + \frac{1}{2}(0,625)(v^2)$$
$$18,68125 = 0,3125\,v^2$$
$$59,78 = v^2$$
$$v = 7,73 \text{ m} \cdot \text{s}^{-1}$$

5.2. $E_{\text{K(new)}} = \left(1 - \frac{15}{100}\right)E_{\text{K(old)}}$

$$\frac{1}{2}mv_{\text{f}}^2 = (0,85)\frac{1}{2}mv_{\text{i}}^2$$
$$\frac{1}{2}(0,625)\,(v_{\text{f}})^2 = (0,85)\left(\frac{1}{2}\right)(0,625)\,(7,73)^2$$
$$0,3125\,v_{\text{f}}^2 = 15,87$$
$$v_{\text{f}}^2 = 50,79$$
$$v_{\text{f}} = 7,13 \text{ m} \cdot \text{s}^{-1}$$

5.3. At the maximum height the basketball would have converted all of its kinetic energy, with which it bounced off the floor, to a gravitational potential energy.

$$\left(mgh + \frac{1}{2}mv^2\right)_{\text{bottom}} = \left(mgh + \frac{1}{2}mv^2\right)_{\text{top}}$$
$$\left(0 + \frac{1}{2}(0,625)\,(7,13)^2\right) = (0,625)(9,8)(h) + 0$$
$$15,89 = 6,126h$$
$$\therefore\ h = 2,59 \text{ m}$$

The basketball will reach a maximum height of 2,59 m after it has lost 15% of its kinetic energy due to the inelastic collision with the floor.

6. We can use the principle of conservation of mechanical energy to calculate the height from which the ball was dropped.

$$\left(mgh + \frac{1}{2}mv^2\right)_{\text{top}} = \left(mgh + \frac{1}{2}mv^2\right)_{\text{bottom}}$$
$$(0,15)(9,8)(h) + 0 = 0 + \frac{1}{2}(0,15)\,(6,2)^2$$
$$1,47h = 2,883$$
$$\therefore\ h = 1,96 \text{ m}$$

The cricket ball was dropped from a height of 1,96 m above the ground. For this ball to pass the test, it must rise to height of $\frac{1}{3}$ of 1,96 m.

Expected maximum height after bouncing:

$$h_{\text{new}} = \frac{1}{3} \times 1,96 = 0,65 \text{ m}$$

Therefore the cricket ball meets the minimum requirements.

Activity 1.10 Power (LB p. 49)

1. Power is the rate at which work is done.
2. Running:

$P = \frac{F\Delta x}{\Delta t}$

$P = \frac{(mg)(\Delta x)}{\Delta t}$

$P = \frac{(50)(9,8)(15)}{5}$

$= 1\ 470$ W

Walking:

$P = \frac{F\Delta x}{\Delta t}$

$P = \frac{(mg)(\Delta x)}{\Delta t}$

$P = \frac{(50)(9,8)(15)}{20}$

$= 367,5$ W

3. Each teacher is doing work against his/ her own weight:

3.1. Mrs Klein:

$P = \frac{F\Delta x}{\Delta t}$

$P = \frac{(mg)(\Delta x)}{\Delta t}$

$P = \frac{(59)(9,8)(3,8)}{18}$

$= 122,06$ W

Mr Broening:

$P = \frac{F\Delta x}{\Delta t}$

$P = \frac{(mg)(\Delta x)}{\Delta t}$

$P = \frac{(115)(9,8)(3,8)}{22}$

$= 194,66$ W

Mrs Austin:

$P = \frac{F\Delta x}{\Delta t}$

$P = \frac{(mg)(\Delta x)}{\Delta t}$

$P = \frac{(55,5)(9,8)(3,8)}{15}$

$= 137,79$ W

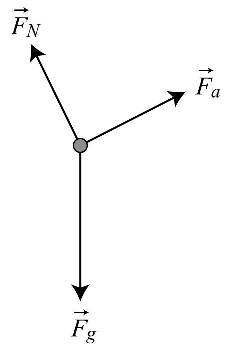
Ranking the power:

Mr Broening; Mrs Austin; Mrs Klein

3.2 In horsepower, each teacher's power will be:

Mrs Klein:

Mrs Klein	Mr Broening	Mrs Austin
$P = \frac{122{,}06}{746}$ $= 0{,}16$ hp	$P = \frac{194{,}66}{746}$ $= 0{,}26$ hp	$P = \frac{137{,}79}{746}$ $= 0{,}18$ hp



4.

4.1 The force applied by the engine on the truck is the same magnitude as the component of the weight parallel to the plane.

$F_a = mg\sin\theta$

But since we don't know the value of the inclination angle, we can define $\sin\theta = \frac{h}{\Delta x}$

Such that the work done by the truck engine is:

$W_a = F_a\Delta x = mg\left(\frac{h}{\Delta x}\right) \times \Delta x = mgh$

The delivered by the truck engine will be:

$P = \frac{W}{\Delta t} = \frac{mgh}{\Delta t}$

$P = \frac{(5\ 000)(9,8)(55)}{60}$

$= 1,80 \times 10^5$ W

$= 180$ kW

4.2 $P = \frac{1,80 \times 10^5}{746}$

$= 241,29$ hp

5.

5.1 Student A

$W = F\Delta x$

$W = (50)(0,4)$

$= 20$ J

Student B:

$$W = F\Delta x$$
$$W = (40)(0,5)$$
$$= 20\ \text{J}$$

Therefore, the students are doing the same amount of work on the respective boxes they are lifting.

5.2 Student B. This student took less amount of time to deliver the same amount of work as student A.

Review activity: Section A: Multiple choice questions

(LB p. 53)

1. C	2. D	3. D	4. C
5. D	6. A	7. A	8. B
9. C	10. B	11. D	12. D
13. B	14. C	15. C	16. B
17. A	18. D		

Review activity: Section B: Long Questions

(LB p. 56)

Newton's Laws of Motion

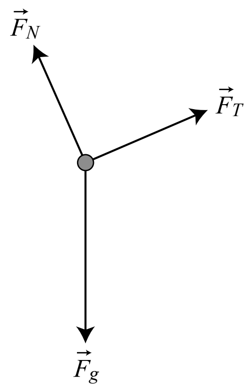
1. This is an example of the application of Newton's first law of motion for an object moving at constant speed along the straight line.
   - 1.1 An object will remain at rest, or continue moving at a constant speed along a straight line, unless acted upon by the net force.
   - 1.2 $0\ \text{m}\cdot\text{s}^{-2}$. The trolley is moving at a constant velocity, and therefore its change in velocity is zero.
   - 1.3 Kinetic frictional force.
   - 1.4 2,1 N. The forces acting on the trolley are balanced because the trolley is moving at a constant velocity.
   - 1.5 $f_k = \mu_k F_N$

     $2,1 = (0,14)F_N$

     $F_N = 15\ \text{N}$

2. This is an example of the application of Newton's first law of motion for an object at rest.

2.1 Let's first draw the free-body diagram of the forces acting on the block;



Because the object remains at rest, the net force acting on the block is zero. Therefore the magnitude of the tension force on the string equals to the magnitude of the component of the weight parallel to the plane.

$$T = mg\sin\theta$$
$$T = (8,5)(9,8)\sin 30°$$
$$T = 41,65 \text{ N}$$

2.2 The magnitude of the normal force equals to the magnitude of the component of weight perpendicular to the plane.

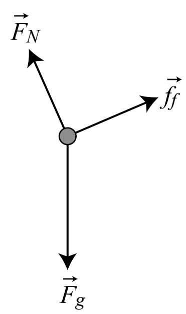
$$F_{\text{N}} - F_{\text{gy}} = 0$$

Therefore

$$F_{\text{N}} = F_{\text{gy}}$$
$$F_{\text{N}} = mg\cos\theta$$
$$F_{\text{N}} = (8,5)(9,8)\cos 30°$$
$$F_{\text{N}} = 72,14 \text{ N}$$

2.3 When the rope is cut, the tension on the string vanishes and the block will accelerate down the slope.

2.3.1 Free-body diagram:



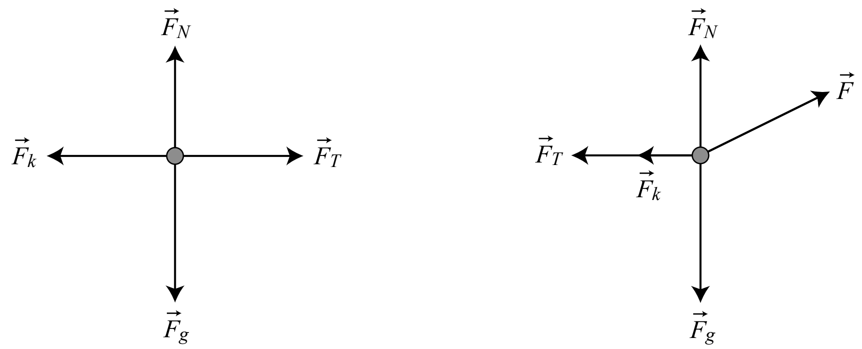
2.3.2 When a net force acts on an object, an object will accelerate in the direction of the net force. The acceleration of an object will be directly proportional to the net force, and inversely proportional to the object's mass.

2.3.3 Let the direction up the incline be negative:

$$F_{\text{net}} = ma$$
$$mg\sin\theta - f_{\text{k}} = ma$$
$$mg\sin\theta - \mu_{\text{k}}F_{\text{N}} = ma$$
$$41,65 - \mu_{\text{k}}(72,14) = (8,5)(3,6)$$
$$41,65 - \mu_{\text{k}}(72,14) = 30,6$$
$$-\mu_{\text{k}}(72,14) = -11,05$$
$$\mu_{\text{k}} = 0,15$$

3.

3.1



3.2 When object A exerts a force on object B, object B simultaneously exerts an oppositely directed force of equal magnitude on object A.

3.3 Let the direction to the right be positive. For a 25 kg block:

$$F_{\text{net}} = ma$$
$$T - f_{\text{k}} = ma$$
$$T - \mu_{\text{k}}mg = ma$$
$$T - (0,2)(25)(9,8) = 25a$$
$$T = 49 + 25a \quad \ldots \quad \ldots(1)$$

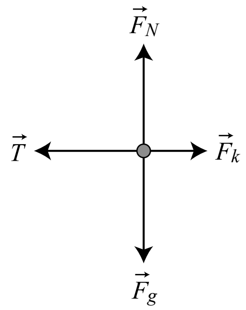
For a 15 kg block:

$$F_{\text{net}} = ma$$
$$F_x - T - f_{\text{k}} = ma$$
$$F\cos\theta - T - \mu_{\text{k}}(mg - F_y) = ma$$
$$(240)(\cos 30°) - (49 + 25a) - (0,2)(15 \times 9,8 - 240\sin 30°) = 15a$$
$$207,85 - 49 - 25a - (32,4) = 15a$$
$$153,45 = 40a$$
$$\therefore\ a = 3,84\ \text{m} \cdot \text{s}^{-2}$$

3.4
$$T = 49 + 25a$$
$$T = 49 + (25)(3,84)$$
$$= 145\ \text{N}$$

4.

4.1



4.2 For the 8 kg block:

$$F_{net} = ma$$
$$mg - T = ma$$
$$(8)(9,8) - T = 8a$$
$$78,4 - 8a = T$$

For the 4 kg block:

$$F_{net} = ma$$
$$T - \mu_k mg = ma$$
$$(78,4 - 8a) - (0,6)(4)(9,8) = 4a$$
$$78,4 - 8a - 23,52 = 4a$$
$$54,88 = 12a$$
$$a = 4,57 \text{ m} \cdot \text{s}^{-2}$$

4.3 $T = 78,4 - 8a$

$$T = 78,4 - (8)(4,57)$$
$$= 41,84 \text{ N}$$

Momentum:

5.

5.1 $F_{net}\Delta t = m(v_f - v_i)$

$$F_{net}(5) = (1\ 000)(30 - 25)$$
$$F_{net}(5) = 5\ 000$$
$$F_{net} = 1\ 000$$

5.2 Opposite direction to the spaceship direction.

6.

6.1 Let the direction towards the wall be positive:

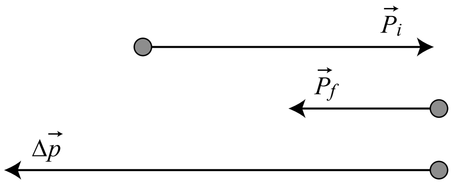
$$F\Delta t = m(v_f - v_i)$$
$$F\Delta t = (0,15)(-12 - 18)$$
$$F\Delta t = -4,5 \text{ N} \cdot \text{s or } 4,5 \text{ N} \cdot \text{s away from the wall}$$

6.2 $F_{\text{net}}\Delta t = \Delta p$

$F_{\text{net}}(0,1) = -4,5$

$F_{\text{net}} = -4,5$ N or $4,5$ N away from the wall

6.3



7.

7.1 The total linear momentum of an isolated system remains constant in magnitude and direction.

7.2 $\sum\vec{p}_{\text{i}} = \sum\vec{p}_{\text{f}}$

$m_1 v_{\text{i1}} + m_2 v_{\text{i2}} = m_1 v_{\text{f1}} + m_2 v_{\text{f2}}$

$(4\ 000)(1,5) + (3\ 000)(0) = (4\ 000)(v_{\text{f1}}) + (3\ 000)(2,8)$

$6\ 000 = (4\ 000)(v_{\text{f1}}) + 8\ 400$

$-2\ 400 = 4\ 000 v_{\text{f1}}$

$v_{\text{f1}} = -0,6\ \text{m} \cdot \text{s}^{-1}$

$= 0,6\ \text{m} \cdot \text{s}^{-1}$ due west

7.3 $\sum K_{\text{i}} = \frac{1}{2}m_1 v_{\text{i1}}^2 + \frac{1}{2}m_2 v_{\text{i2}}^2$

$\sum K_{\text{i}} = \frac{1}{2}(4\ 000)(1,5)^2 + \frac{1}{2}(3\ 000)(0)^2$

$= 4\ 500$ J

$\sum K_{\text{f}} = \frac{1}{2}m_1 v_{\text{f1}}^2 + \frac{1}{2}m_2 v_{\text{f2}}^2$

$\sum K_{\text{i}} = \frac{1}{2}(4\ 000)(0,6)^2 + \frac{1}{2}(3\ 000)(2,8)^2$

$= 720 + 11\ 760$

$= 12\ 480$ J

The collision is inelastic.

8.

8.1 $\sum\vec{p}_{\text{i}} = \sum\vec{p}_{\text{i}}$

$m_1 v_{\text{i1}} + m_2 v_{\text{i2}} = (m_1 + m_2) v_{\text{f}}$

$(40)(5) + (2)(0) = (40 + 2) v_{\text{f}}$

$200 = 42 v_{\text{f}}$

$v_{\text{f}} = 4,76\ \text{m} \cdot \text{s}^{-1}$

9.

9.1 The force the gases ejected by engine exert on the ground is the action force, while the upward force exerted by the ground on the rocket is the reaction force.

9.2

9.2.1 The total linear momentum of an isolated system remains constant in magnitude and direction.

9.2.2 $\sum\vec{p}_i = \sum\vec{p}_i$

$(m_B + m_A)v_i = m_B v_{fB} + m_2 v_{fA}$

$(2 + 3)(5) = (2)(8) + (3)v_{fA}$

$25 = 16 + 3v_{fA}$

$9 = 3v_{fA}$

$v_{fA} = 3 \text{ m} \cdot \text{s}^{-1}$

10. Here the brick has a zero horizontal velocity because it is falling vertically downwards. The velocity with which the brick land on the trolley doesn't contribute to the total momentum of the system.

$\vec{p}_i = \sum\vec{p}_f$

$m_1 v_{i1} + m_2 v_{i2} = (m_1 + m_2)v_f$

$(3)(4) + (1)(0) = (3 + 1)v_f$

$12 = 4v_f$

$v_f = 3 \text{ m} \cdot \text{s}^{-1}$

11. When a car hits the wall and bounce back, that car will have a bigger change in momentum than the car that hits the wall, crumples and stops. Situation B will cause more damage than situation A, because when the car hits the wall and bounce back, the passengers inside the car will continue moving towards the wall with the same speed as that of a car before hitting the wall. Furthermore, the force exerted by the wall on the car is bigger is situation A than situation B because the change in momentum in situation A is more than the change in momentum in situation B. Crumpling increases the contact time between the wall and the car, thereby decreasing the force the wall exerts on the car.

Work, Energy and Power

12.

12.1 $W = F\Delta x \cos\theta$

$W = (220)(10)\cos 0°$

$W = 2\ 200 \text{ J}$

12.2 $W = F\Delta x \cos\theta$

$W = (mg)\Delta x \cos 90°$

$W = 0 \text{ J}$

12.3 $W = F\Delta x \cos\theta$

$W = (40)(10)\cos 180°$

$W = -400 \text{ J}$

12.4 $\vec{F}_{\text{net}} = \vec{F}_a + \vec{f}_k$

$\vec{F}_{\text{net}} = 220 + (-40)$

$= 180$ N

12.5 $W = F\Delta x\cos\theta$

$W = (180)(10)\cos 0°$

$W = 1\ 800$ J

13. We first should convert power to watt and minute to second.

$P = 0,5\text{ hp} = 0,5\text{ hp} \times \frac{746\text{ W}}{1\text{ hp}} = 373\text{ W}$

$\Delta t = 60\text{ s}$

The electric pump is doing work against the weight of the water. So it exert on the water must at least be equal to the weight of the water.

$P = \frac{W}{\Delta t}$

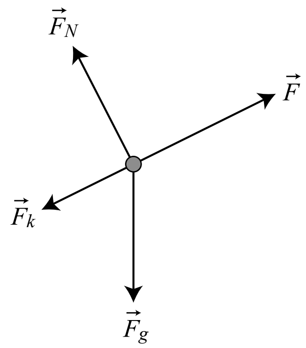
$P = \frac{mgh}{\Delta t}$

$373 = \frac{(m)(9,8)(80)}{60}$

$m = 28,54\text{ kg}$

14.

14.1



14.2 Let the direction up the slope be positive.

$\vec{F}_{\text{net}} = 0$

$-F_{gx} - f_k + F_a = 0$

$-mg\sin\theta - f_k + F_a = 0$

$-(1\ 400)(9,8)(\sin 10°) - 700 + F_a = 0$

$-30\ 82,45 + F_a = 0$

$F_a = 3\ 082,45\text{ N}$

14.3 $v = \frac{90}{3,6}\text{ m}\cdot\text{s}^{-1} = 25\text{ m}\cdot\text{s}^{-1}$

$P = Fv$

$P = (30\ 82,45)(25)$

$= 77\ 061,25\text{ W}$

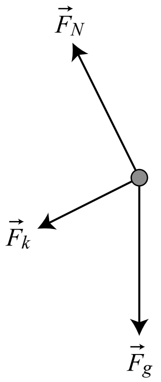
15.

15.1 The total linear momentum of an isolated system remains constant in magnitude and direction.

15.2 Let the direction to the east be positive.

$$\sum\vec{p}_i = \sum\vec{p}_f$$
$$m_1 v_{i1} + m_2 v_{i2} = m_1 v_{f1} + m_2 v_{f2}$$
$$(3)(v_{i1}) + (6)(0) = (3)(-0,5) + (6)(2,25)$$
$$3v_{i1} = 12$$
$$v_{i1} = 4\ \text{m}\cdot\text{s}^{-1}$$

15.3



15.4 No. Because of the presence of frictional force in the system, which is an external force.

15.5 $E_M = mgh + \frac{1}{2}mv^2$

$E_M = 0 + \frac{1}{2}(6)(2,25)^2$

$= 15,19$ J

15.6 $E_M = mgh + \frac{1}{2}mv^2$

$E_M = (6)(9,8)(0,12) + 0$

$= 7,056$ J

15.7 $W_f = E_{M(top)} - E_{M(bottom)}$

$W_f = 7,056 - 15.19$

$= -8,13$ J

15.8 $W_f = f_k \Delta x$

$-8,13 = (10)\ \Delta x\ (-1)$

$\Delta x = 0,813$ m

16. Work done equal to the area enclosed by the force-displacement graph.

16.1 $W = \text{Area} = (L \times b) + \frac{1}{2}(b \times h)$

$W = 6 \times 3 + \frac{1}{2}(3 \times 6)$

$W = 18 + 9$

$= 27$ J

17.

17.1 The Principle of conservation of mechanical energy states that the total mechanical energy of an isolated system remains constant.

17.2
$$E_M = mgh + \frac{1}{2}mv^2$$
$$E_M = (10)(9,8)(5) + 0$$
$$E_M = 490 \text{ J}$$

17.3
$$E_M = mgh + \frac{1}{2}mv^2$$
$$490 = 0 + \frac{1}{2}(10)(v^2)$$
$$490 = 5v^2$$
$$98 = v^2$$
$$v = 9,90 \text{ m} \cdot \text{s}^{-1}$$

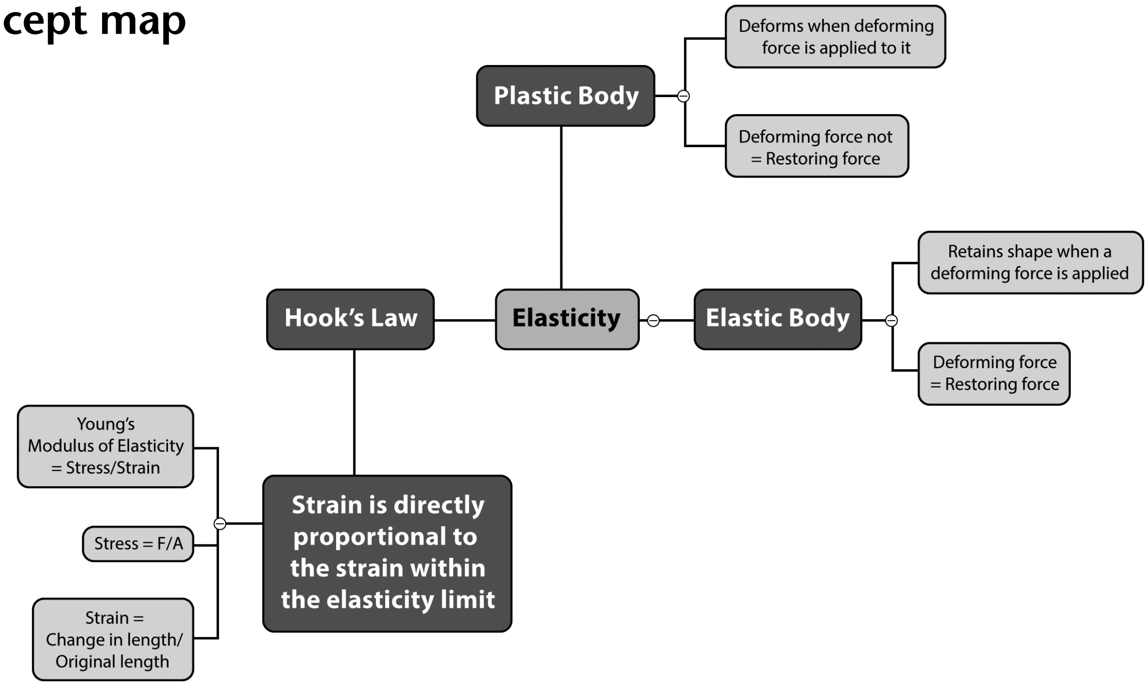
17.4
$$E_M = mgh + \frac{1}{2}mv^2$$
$$490 = (10)(9,8)(2) + \frac{1}{2}(10)(v^2)$$
$$490 = 196 + 5v^2$$
$$294 = 5v^2$$
$$58,8 = v^2$$
$$v = 7,67 \text{ m} \cdot \text{s}^{-1}$$

2 Mechanics: Elasticity

CHAPTER OVERVIEW

This chapter introduces concepts of elasticity. The following concepts are outlined in the chapter: (Deforming force, restoring force, elasticity, perfectly elastic body, elastic limit, stress, strain, Hooke's Law,), Viscosity (effect of temperature on viscosity, motor oil viscosity grades).

Concept map



Suggested answers

Activity 2.1 Stress and strain *(LB p. 64)*

1.

1.1 Elasticity of a body is the property of the body by virtue of which the body regains its original shape and size when the deforming force is remove.

1.2 Deforming force is a force that changes the shape of an object.

1.3 Restoring force is a force developed inside the body which tries to bring the body back into its initial size and shape.

1.4 Perfectly elastic body is a body which regains its original shape and size completely when the deforming force is removed

1.5 Perfectly plastic body is a body which does not show a tendency to regain its original shape and size when the deforming force is removed.

1.6 Stress refers to the internal restoring force per unit cross-sectional area of body.

1.7 Strain is defined as the ratio of change in dimension to the original dimension.

2.

2.1 $\sigma = \frac{F}{A}$

$$\sigma = \frac{20}{\pi \times \left(\frac{0,36}{2} \times 10^{-3}\right)^2}$$

$= 1,961 \times 10^7$ Pa

2.2 $\Delta l = 25,055 - 25 = 0,055$ m

$\varepsilon = \frac{\Delta l}{l}$

$\varepsilon = \frac{0,055}{25}$

$= 2,2 \times 10^{-3}$

2.3 $\sigma = \frac{F}{A}$

$$\sigma = \frac{10}{\pi \times \left(2 \times \frac{0,36}{2} \times 10^{-3}\right)^2}$$

$= 2,46 \times 10^7$ Pa

$= 24,6$ MPa

3.

3.1 $\sigma = \frac{F}{A}$

$$\sigma = \frac{12}{\pi \times \left(\frac{2,5}{2} \times 10^{-3}\right)^2}$$

$= 2,44 \times 10^6$ Pa

$= 24,6$ MPa

4.

4.1 $\varepsilon = \frac{\Delta l}{l}$

$\varepsilon = \frac{0,06 \times 10^{-3}}{0,5}$

$= 1,2 \times 10^{-4}$

4.2 $\sigma = \frac{F}{A}$

$152,8 \times 10^6 = \frac{20 \times 10^3}{\pi r^2}$

$\pi r^2 = \frac{20 \times 10^3}{152,8 \times 10^6}$

$\pi r^2 = 1,31 \times 10^{-4}$

$r^2 = 4,166 \times 10^{-5}$

$r = 6,45 \times 10^{-3}$ m

$d = 2r$

$\therefore\ d = 2 \times 6,45 \times 10^{-3}$ m

$d = 1,29 \times 10^{-2} = 12,9$ mm

Activity 2.2 Hooke's Law *(LB p. 67)*

1.

1.1 $\sigma = \frac{F}{A}$

$\sigma = \frac{89}{(20 \times 10^{-3})^2}$

$\sigma = 2,225 \times 10^5$ Pa

1.2 $\varepsilon = \frac{\Delta l}{l}$

$\varepsilon = \frac{0,10 \times 10^{-3}}{100 \times 10^{-3}}$

$= 1,00 \times 10^{-3}$

1.3 $K = \frac{\sigma}{\varepsilon}$

$K = \frac{2,225 \times 10^5}{1,000 \times 10^{-3}}$

$K = 2,225 \times 10^8$ Pa

$K = 222,5$ MPa

2.

2.1 $K = \frac{\sigma}{\varepsilon}$

$205 \times 10^9 = \frac{280 \times 10^6}{\varepsilon}$

$\varepsilon = 1,37 \times 10^{-3}$

2.2 $\sigma = \frac{F}{A}$

OR

$F = \sigma A$

$280 \times 10^6 = \frac{F}{\pi \times \left(\frac{80}{2} \times 10^{-3}\right)^2}$

$F = 1,41 \times 10^6$ N

3. Let's first calculate the stress on the cylinder.

$\sigma = \frac{F}{A}$

$\sigma = \frac{2\ 000}{\pi \times \left(\frac{3,8}{2} \times 10^{-3}\right)^2}$

$\sigma = 1,7635 \times 10^8$ Pa

$\sigma = 176,35$ MPa

From the modulus of elasticity we can calculate the strain on the cylindrical specimen.

$K = \frac{\sigma}{\varepsilon}$

$107 \times 10^9 = \frac{1,7635 \times 10^8}{\varepsilon}$

$\varepsilon = 1,648 \times 10^{-3}$ Pa

$\varepsilon = \frac{\Delta l}{l}$

$1,648 \times 10^{-3} = \frac{0,42 \times 10^{-3}}{l}$

$l = 0,2548$ m

$= 25,48$ mm

4.

4.1 $\sigma = \frac{F}{A}$

$275 \times 10^6 = \frac{F}{325 \times 10^{-6}}$

$F = 8,94 \times 10^4$ N

$F = 89,4$ kN

4.2 $K = \frac{\sigma}{\varepsilon}$

$115 \times 10^9 = \frac{275 \times 10^6}{\varepsilon}$

$\varepsilon = 2,39 \times 10^{-3}$

$\varepsilon = \frac{\Delta l}{l}$

$2,39 \times 10^{-3} = \frac{\Delta l}{115}$

$\Delta l = 0,275$ mm

The maximum length to which the specimen will be stretch without deforming will be:

$l_{max} = l + \Delta l$

$l_{max} = 115 \text{ mm} + 0,275 \text{ mm} = 115,275 \text{ mm}$

5. $\sigma = \frac{F}{A}$

$\sigma = \frac{12}{\pi \times \left(\frac{1,5}{2} \times 10^{-3}\right)^2}$

$\sigma = 6,79 \times 10^6$ Pa

$\sigma = 6,79$ MPa

$K = \frac{\sigma}{\varepsilon}$

$8,96 \times 10^{11} = \frac{6,79 \times 10^6}{\varepsilon}$

$\varepsilon = 7,58 \times 10^{-6}$

$\varepsilon = \frac{\Delta l}{l}$

$7,58 \times 10^{-6} = \frac{\Delta l}{8}$

$\Delta l = 6,06 \times 10^{-5}$ m

Review activity *(LB p. 69)*

Multiple choice questions

1. B 2. C 3. A 4. B

Long questions

1. A perfectly elastic body is a body which regains its original shape and size completely when the deforming force is removed. Perfect elasticity is an approximation of the real world. Quartz fibre and phosphorus bronze are examples of a perfectly elastic body.

   A perfectly plastic body is a body which does not show a tendency to regain its original shape and size when the deforming force is removed. Wax and putty are examples of a perfectly plastic body.

2.
   2.1. Strain is the ratio of the increases in length of a specimen to the original length when the external is applied to it.

   2.2. $\Delta l = \frac{0,01}{100} \times 1\ 000$ m

   $\Delta l = 0,1$ m

   $\varepsilon = \frac{\Delta l}{l}$

   $\varepsilon = \frac{0,1}{1\ 000}$

   $\varepsilon = 1 \times 10^{-4}$

   2.3 Because the units of the change in length and the length are the same. When calculating strain, which is the ratio between the change in length and the original length of the specimen, the units cancel out and the answer therefore has no units.

   2.4. Hooke's Law states that within the limit of elasticity, stress is directly proportional to strain.

   2.5 $K = \frac{\sigma}{\varepsilon}$

   $2 \times 10^{11} = \frac{\sigma}{1 \times 10^{-4}}$

   $\sigma = 2 \times 10^{7}$ Pa

   $\sigma = 20$ MPa

3.
   3.1 An elastic limit is the maximum force that can be applied to body so that the body regains its original form completely on removal of the force.

   3.2 $\sigma = \frac{F}{A}$

   $\sigma = \frac{mg}{\pi r^2}$

   $\sigma = \frac{4,5 \times 9,8}{\pi \times \left(\frac{1}{2} \times 10^{-3}\right)^2}$

   $\sigma = \frac{44,1}{\pi \times 2,5 \times 10^{-7}}$

   $\sigma = 5,61 \times 10^{7}$ Pa

   $\sigma = 56,1$ MPa

3.3 $\varepsilon = \frac{\Delta l}{l}$

$\varepsilon = \frac{1 \text{ mm}}{2\ 000 \text{ mm}}$

$\varepsilon = 5 \times 10^{-4}$

3.4 $K = \frac{\sigma}{\varepsilon}$

$K = \frac{5,61 \times 10^{7}}{5 \times 10^{-4}}$

$K = 1,122 \times 10^{11} \text{ Pa}$

4.

4.1 $\sigma = \frac{F}{A}$

$\sigma = \frac{12}{\pi \times \left(\frac{2,5}{2} \times 10^{-3}\right)^{2}}$

$\sigma = 2,44 \times 10^{6} \text{ Pa} = 2,44 \text{ MPa}$

4.2 $\varepsilon = \frac{\Delta l}{l}$

$\varepsilon = \frac{0,3 \text{ mm}}{2\ 000 \text{ mm}}$

$\varepsilon = 1,5 \times 10^{-4}$

4.3 $K = \frac{\sigma}{\varepsilon}$

$K = \frac{2,44 \times 10^{6}}{1,5 \times 10^{-4}}$

$K = 1,63 \times 10^{10} \text{ Pa}$

5.

5.1 $\sigma = \frac{F}{A}$

$18 \times 10^{6} = \frac{45000}{A}$

$A = 2,5 \times 10^{-4} \text{ m}^{2}$

$A = \pi r^{2}$

$2,5 \times 10^{-4} = \pi r^{2}$

$7,96 \times 10^{-5} = r^{2}$

$8,92 \times 10^{-3}\ m = r$

$\therefore\ r = 8,92 \text{ mm}$

$d = 2r = 17,84 \text{ mm}$

5.2 $K = \frac{\sigma}{\varepsilon}$

$90 \times 10^{6} = \frac{18 \times 10^{6}}{\varepsilon}$

$\varepsilon = 0,2$

5.3 $\varepsilon = \frac{\Delta l}{l}$

$0,2 = \frac{\Delta l}{185 \text{ mm}}$

$\Delta l = 37 \text{ mm}$

6.

6.1 $\sigma = \frac{F}{A}$

$16 \times 10^6 = \frac{F}{1,26 \times 10^{-3}}$

$F = 2,016 \times 10^4 \text{ N}$

6.2 $\varepsilon = \frac{\Delta l}{l}$

$\varepsilon = \frac{1,44 \times 10^{-3} \text{ mm}}{80 \text{ mm}}$

$= 1,80 \times 10^{-5}$

6.3 $K = \frac{\sigma}{\varepsilon}$

$K = \frac{16 \times 10^6}{1,80 \times 10^{-5}}$

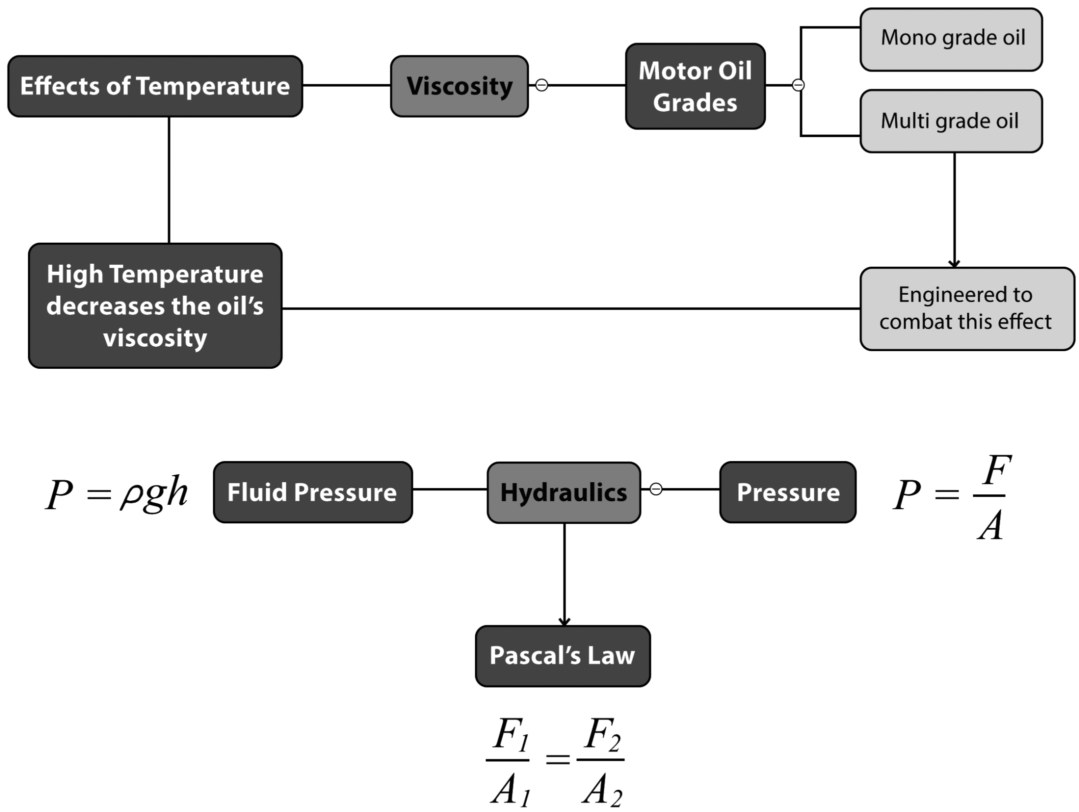
$K = 8,89 \times 10^{11} \text{ Pa}$

3 Mechanics: Hydraulics

CHAPTER OVERVIEW

This chapter introduces a concept of hydraulics by outlining the following topics: the thrust, pressure, practical unit of pressure, fluid pressure, Pascal's Law, hydraulic lift).

Concept map



Suggested answers

Activity 3.1 Viscosity

(LB p. 75)

1. Viscosity is the property of the fluid to oppose relative motion between the two adjacent layers.
2. As the temperature of the liquid fluid increases its viscosity decreases, and the fluid (such as the oil) loses its ability to lubricate.
3. When the engine is still cold, when it has just started, low-viscosity oil is of an advantage in that it can flow fast to oil the engine parts that need lubrication. However, at high temperatures (when the engine has been running long enough) the low-viscosity oil is a disadvantage because it can is a good lubricant. It flows too fast and may cause the engine parts to corrode with ease.

4. Monograde oil is the engine oil that is designed to function at either low temperatures or high temperatures and cannot be suitable for changing engine temperatures. For example, SAE 40 oil is a monograde oil.

   Multi-grade oil is an engine oil that is designed to cope with the increasing engine temperatures. It behaves as a low viscosity oil at lower temperatures and as a high viscosity oil at high temperatures. For example, 20W50 SAE is an engine oil that behaves as SAE 20 when the engine is cold, and as a SAE 50 when the engine heats up.

5. 15W40 SAE is the oil that behaves as an SAE 15 oil at low temperatures, and behaves as an SAE 40 at high temperatures.

Activity 3.2 Pressure *(LB p. 78)*

1. Hydraulics (fluid mechanics) is a topic in applied science and engineering dealing with mechanical properties of liquids.

2.
   2.1. A thrust is the normal force exerted by a liquid at rest on a given surface in contact with it.

   2.2. Pressure at a particular point is the thrust acting on the unit area around that point.

   2.3 A substance that has no fixed shape and yields easily to external pressure; a gas or a liquid.

   OR

   A fluid is a substance that continually deforms (flows) under an applied stress.

3.

- Liquids conform to the shape of a container.
- Liquids are generally incompressible.
- Liquids exert pressure in all directions.

4. A tooth in its tube is a fluid enclosed in a container. When a thumb exert a force over a certain area on the tube, pressure is created. This pressure will be transmitted equally around the tube, and that's how the pressure get to the mouth of a tube.

5. $P = \frac{F}{A}$

$$P = \frac{2400}{\left(2 \times \frac{50}{100}\right)}$$

$$P = \frac{2400}{1} = 2400 \text{ Pa}$$

$$P = \frac{2400}{133} \text{ torr} = 18{,}05 \text{ torr}$$

6.

   6.1 $P = \frac{F}{A}$

$$P = \frac{mg}{A}$$

$$P = \frac{(50)(9{,}8)}{(100 \times 10^{-4})}$$

$$P = 49\ 000 \text{ Pa}$$

Activity 3.3 Fluid pressure (LB p. 79)

1. The density (ρ) of a substance is defined as a mass of a substance per unit volume of the substance.

2. It is the pressure exerted by the fluid on a body due to the fluids weights, volume and height.

3. $P = \rho gh$

   $P = (1 \times 10^3)(9,8)(9) = 88\ 200 \text{ Pa}$

4. $P = \rho gh$

   $P = (1027)(9,8)(100)$

   $P = 1,00646 \times 10^6 \text{ Pa}$

   $P = \frac{1,00646 \times 10^6}{1,01325 \times 10^5} \text{ atm} = 9,9 \text{ atm}$

5. $P = \rho gh$

   $P = (1\ 050)(9,8)(3\ 800)$

   $P = 3,9102 \times 10^7 \text{ Pa}$

6. $P = \rho gh$

   $735 = \rho(9,8)(2,5)$

   $\rho = 30\ kg \cdot m^{-3}$

Activity 3.4 Pascal's law (LB p. 82)

1. Pascal's law states that in a continuous liquid at equilibrium, the pressure applied at any point is transmitted equally to other parts of the liquid.

2. There's no for unit conversion as long as the areas are expressed in same measuring units.

   $\frac{F_1}{A_1} = \frac{F_2}{A_2}$

   $\frac{5}{1,2} = \frac{F_2}{120}$

   $F_2 = \frac{5}{1,2} \times 120$

   $F_2 = 500 \text{ N}$

3.

   $\frac{F_1}{A_1} = \frac{F_2}{A_2}$

   $\frac{100}{0,01} = \frac{F_2}{0,1}$

   $F_2 = \frac{100}{0,01} \times 0,1$

   $F_2 = 1000 \text{ N}$

This is the combined weight of the chair and the customer. Their combined mass is calculated as follows:

$$w = mg$$

$$1000 = m(9,8)$$

$$m = 102,04 \text{ kg}$$

Therefore, the mass of the customer is:

$$m = 102 - 5 = 97 \text{ kg}$$

4. $$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$\frac{F_1}{0,03} = \frac{2\ 000 \times 9,8}{0,5}$$

$$F_1 = \frac{2\ 000 \times 9,8}{0,5} \times 0,03$$

$$F_1 = 1\ 176\ N$$

5. $$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$\frac{F_1}{400} = \frac{54 \times 9,8}{600}$$

$$F_1 = \frac{54 \times 9,8}{600} \times 400$$

$$F_1 = 352,8 \text{ N}$$

Review activity

(LB p. 85)

Multiple choice questions

1. C
2. B
3. A
4. C
5. B

Long questions

1.

   1.1 Liquids conform to the shape of a container, Liquids are generally incompressible, and Liquids exert pressure in all directions.

   1.2 Viscosity is the property of the fluid to oppose relative motion between the two adjacent layers.

   1.3 As the temperature of the liquid fluid increases its viscosity decreases, and the fluid (such as the oil) loses its ability to lubricate.

2.

   2.1. Multi-grade oil is an engine oil that is designed to cope with the increasing engine temperatures. It behaves as a low viscosity oil at lower temperatures and as a high viscosity oil at high temperatures. For example, 20W50 SAE is an engine oil that behaves as SAE 20 when the engine is cold, and as a SAE 50 when the engine heats up.

1. $$P = \frac{F}{A}$$

$$4 \times 200 \times 10^3 = \frac{1,2 \times 10^4}{A}$$

$A = 0,015 \text{ m}^2$

2. $P = \frac{F}{A}$

$P = \frac{mg}{\pi r^2}$

$P = \frac{(50)(9,8)}{\pi\left(\frac{0,5}{2} \times 10^{-2}\right)^2}$

$P = 2,50 \times 10^6 \text{ Pa}$

3. $P = \frac{F}{A}$

$P = \frac{mg}{4\pi r^2}$

$1,013 \times 10^5 = \frac{(m)(9,8)}{4 \times \pi \times (6,37 \times 10^6)^2}$

$m = 5,27 \times 10^{18} \text{ kg}$

4.

4.1 $P = \frac{F}{A}$

$35 \times 10^6 = \frac{(100)(9,8)}{\pi r^2}$

$r^2 = 8,91 \times 10^{-6}$

$r = 2,99 \times 10^{-3} \text{ m} = 2,99 \text{ mm}$

$\therefore\ d = 2 \times 2,99 \text{ mm} = 5,98 \text{ mm}$

4.2 $P = \frac{F}{A}$

$150 \times 10^3 = \frac{mg}{\pi r^2}$

$150 \times 10^3 = \frac{(m)(9,8)}{\pi(8,91 \times 10^{-6})}$

$m = 0,43 \text{ kg}$

5. $P = \rho g h$

$P = (1 \times 10^3)(9,8)(2) = 1,96 \times 10^4 \text{ Pa}$

6. Weight of the car is $F_2 = mg$, and the bigger pistol is A_2

$\frac{F_1}{A_1} = \frac{F_2}{A_2}$

$\frac{F_1}{\pi(6)^2} = \frac{(1\ 300)(9,8)}{\pi(25)^2}$

$F_1 = 733,82 \text{ N}$

7.

7.1. $\frac{F_1}{A_1} = \frac{F_2}{A_2}$

$\frac{F_1}{\pi(5)^2} = \frac{13\ 300}{\pi(15)^2}$

$F_1 = 1,48 \times 10^3 \text{ N}$

8.

8.1 $P = \frac{F}{A}$

$$P = \frac{80}{\pi\left(\frac{40}{2} \times 10^{-3}\right)^2}$$

$$P = 6{,}37 \times 10^4 \text{ Pa}$$

8.2 $\frac{F_2}{A_2} = 6{,}37 \times 10^4$

$$\frac{320}{\pi r^2} = 6{,}37 \times 10^4$$

$$\pi r^2 = 5{,}0235 \times 10^{-3}$$

$$r^2 = 1{,}6 \times 10^{-3}$$

$$r = 4 \times 10^{-2} \text{ m} = 40 \text{ m}$$

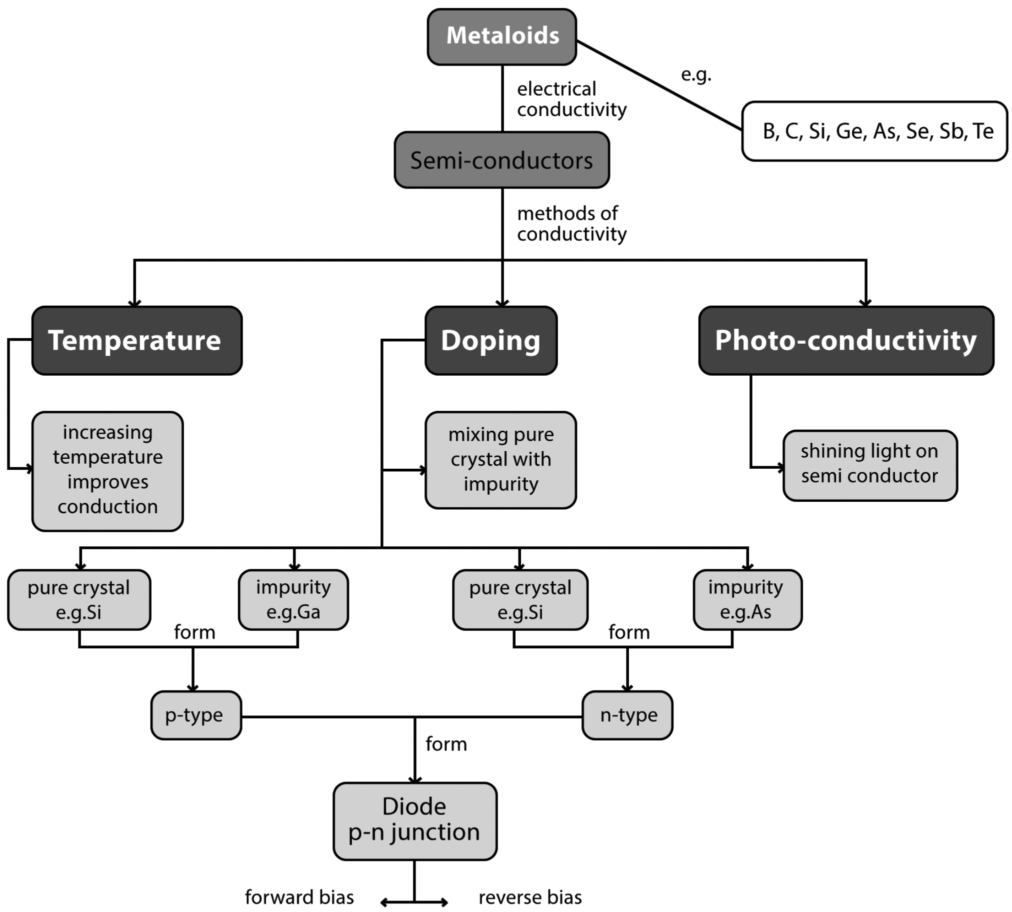
$$\therefore d = 80 \text{ mm}$$

4 Matter and material – Electronic properties of matter

CHAPTER OVERVIEW

Semiconductors have had a great impact on our society. Semiconductors are found at the heart of microprocessor chips as well as transistors. Any product that is computerized or uses radio waves depends on semiconductors. Many electrical appliances have a little red or green light that glows, to tell you that the appliance is connected. This little light is a light-emitting diode or LED, such as you see in picture shown above. The red LED and the transistor and amplifier in the picture all contain small pieces of semi-conductor material. This chapter aims to introduce you the semiconductors, how they are constructed and used to improve life as we know it today.

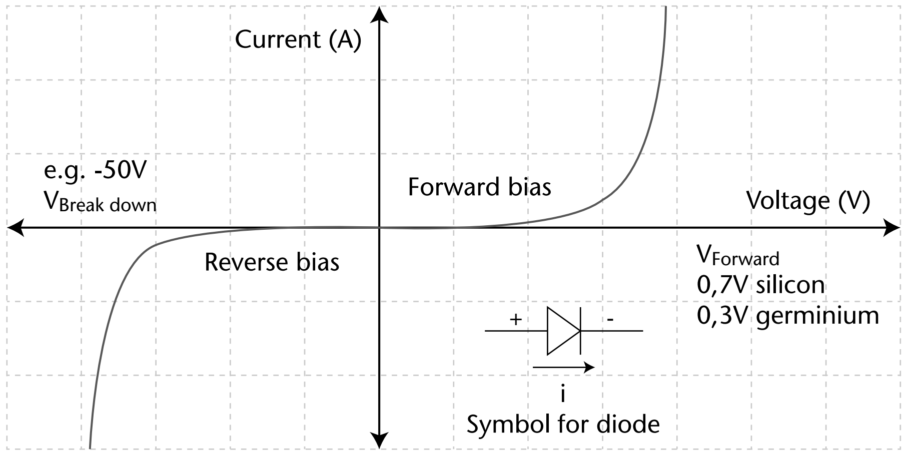
Concept map



Suggested answers

Experiment 5: Discussion

(LB p. 98)

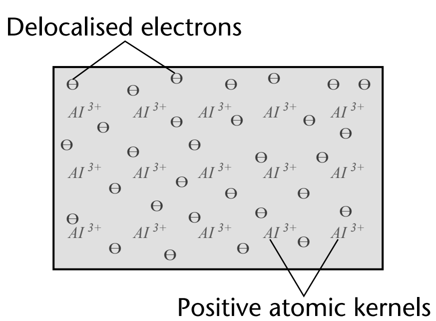


- If, we just reverse the diode to measure the I-V characteristics, the sudden change might destroy the diode.
- The diode should not be short-circuited. That will allow a flow of huge current which might destroy the diode.
- Current must not pass through it for a very long time. It will then increase the depletion region and develop a fluctuating resistance

Review activity

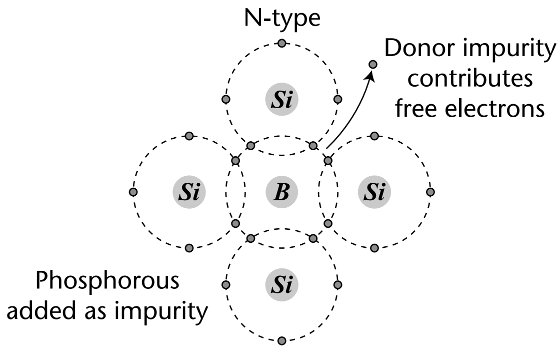
(LB p. 102)

1. Valence electrons
2. A semiconductor is a material which has electrical conductivity between that of a conductor and an insulator such as glass.
3. Silicon (Si) and germanium (Ge)
4. The conductivity of metals is based on the free electrons (so-called delocalised electrons) due to the metal bonding as shown below. Insulators possess no free charge carriers and thus are non-conductive.

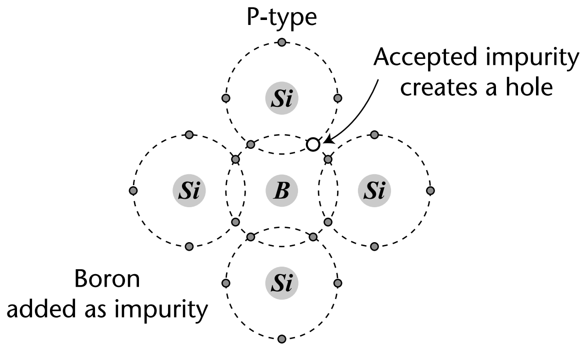


5. Doping is the process of adding impurities to intrinsic semiconductors.

6. N-type semiconductor is formed when a pentavalent impurities such as antimony, arsenic or phosphorous are added to silicon. These elements contribute free electrons, greatly increasing the conductivity of the intrinsic semiconductor.

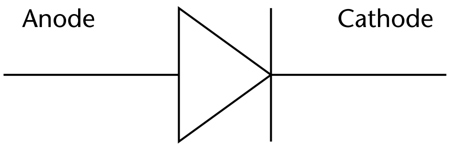


On the other hand, p-type semiconductor is prepared by doping of trivalent impurities such as boron, aluminum or gallium to silicon. These impurities create deficiencies of valence electrons, called ‘holes’ as shown below.



7. A diode is the simplest possible semiconductor device. It allows electric current to flow only in one direction.

8. A p-n junction diode is a junction of an n-type and p-type material that inhibits or allows the current in one direction based on its bias.

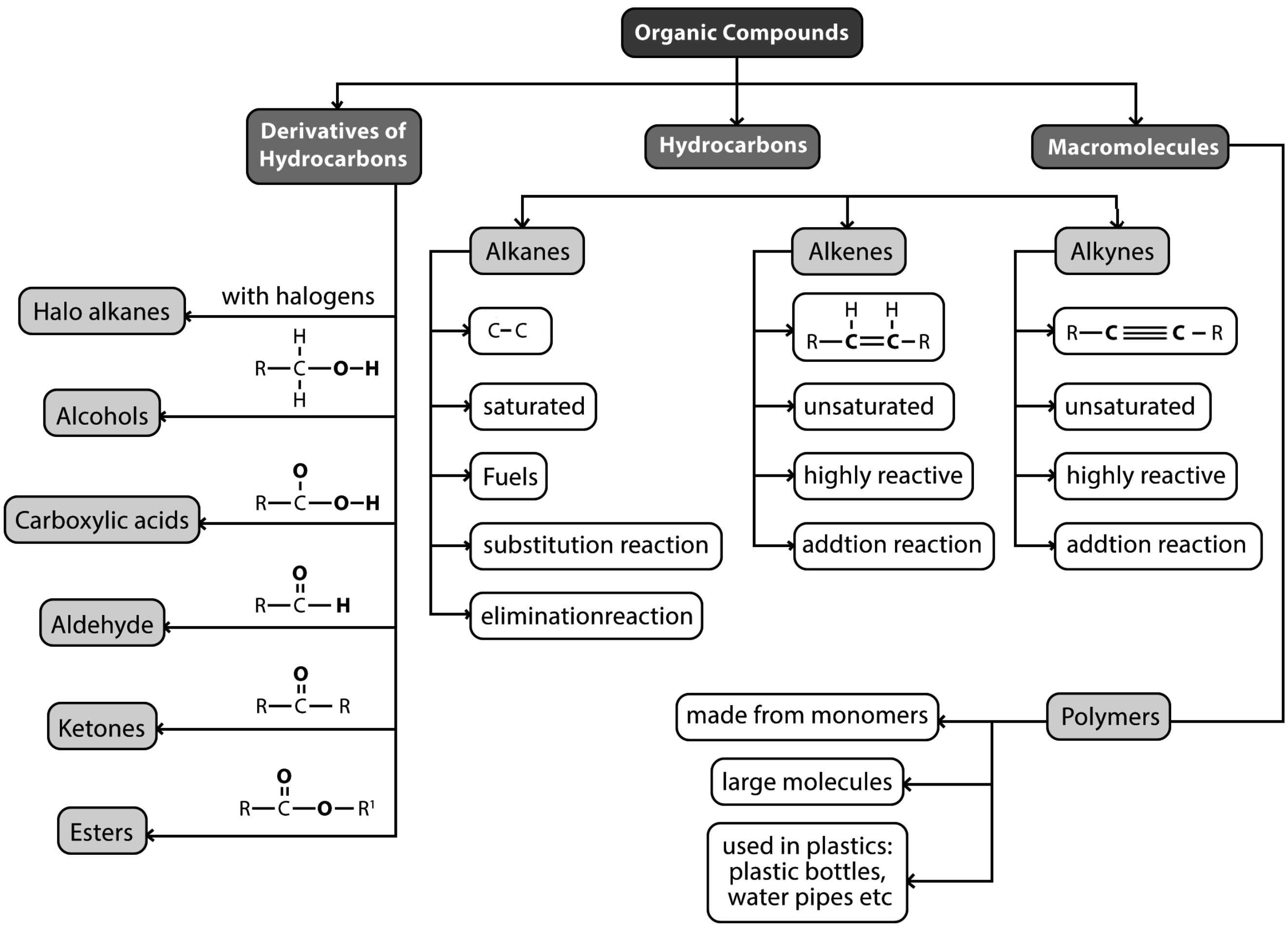


5 Matter and material – Organic chemistry

CHAPTER OVERVIEW

Carbon and Silicon (group 4 elements), form the basis of most natural substances. Silicon forms rings that form the basis for most rocks, sands and soils. Carbon on the other hand has the unusual ability to bond strongly to itself to form long chains and rings. In addition, carbon also forms strong bonds with other non-metals such as hydrogen, nitrogen and oxygen. These bonding properties result in a variety of carbon compounds most of which are known. Carbon-containing compounds are all around us. They are central to the manufacturing of products such as rubber, plastics, fuel, cosmetics, detergents to name but a few.

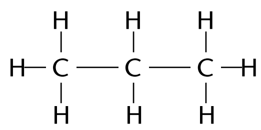
Concept map

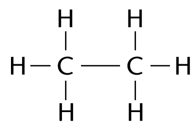


Suggested answers

Activity 5.1: Representing organic compounds *(LB p. 107)*

1.

a) 

b) 

2.

a) C_4H_6

b) C_4H_8

Activity 5.2: Hydrocarbons *(LB p. 111)*

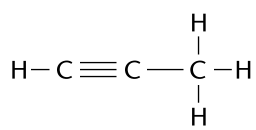
1. Alkane are organic compounds that contain a single bond between the carbon atoms. They are saturated hydrocarbons. Alkenes are organic compound that contain a double bond between the carbon atoms. Alkenes are unsaturated hydrocarbons. Alkynes are organic compound that contain a triple bond between the carbon atoms. Alkynes are unsaturated hydrocarbons.

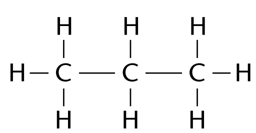
2.

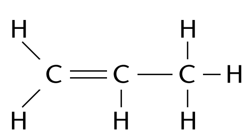
Hydrocarbons	General formula
Alkanes	C_nH_{2n+2} where n is the number of carbons
Alkenes	C_nH_{2n} where n is the number of carbons
Alkynes	C_nH_{2n-2} where n is the number of carbons

3. Alkanes are saturated, but alkenes and alkynes are unsaturated

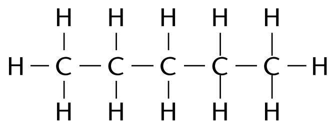
4.

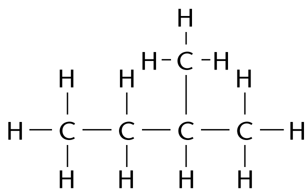
a) 

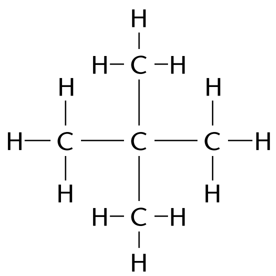
b) 

c) 

5. Any two of the three isomers below



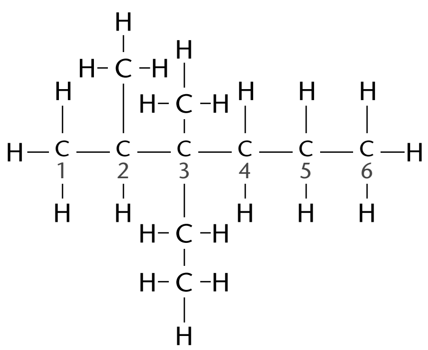




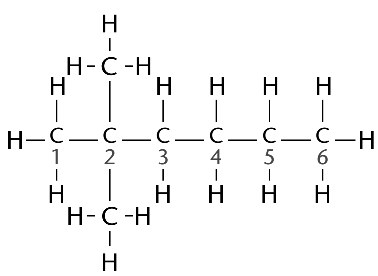
Activity 5.3: Naming hydrocarbons *(LB p. 116)*

1.

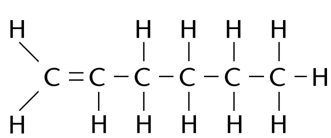
a)



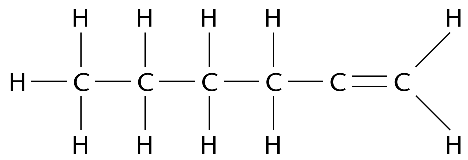
b)



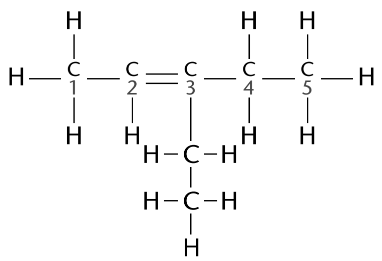
c) Hex-1-ene



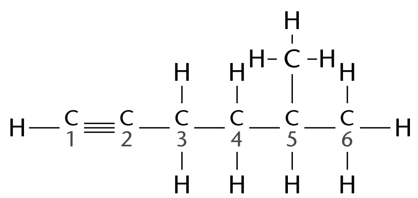
Or



d) 3-ethyl-pent-2-ene



e) 5-methylhex-1-yne



2.

a) 3-ethyl-4-methylhaxane

b) 3,3-dimethylpentane

c) buta-1,3-diene

d) prop-1-ene

Activity 5.4: Naming haloalkanes *(LB p. 119)*

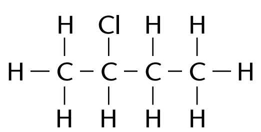
1.

a) 2-iodopropane

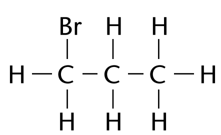
b) 1-fluoro-2,2-diiodobutane

2.

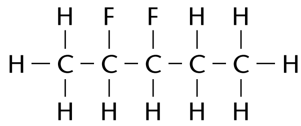
a) 2-chlorobutane



b) 1-bromopropane



c) 2,3-difluoropentane

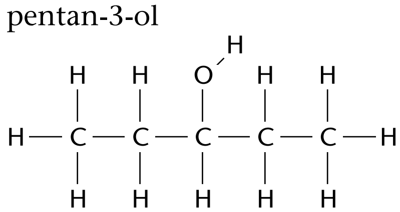


Activity 5.5: Naming alcohols

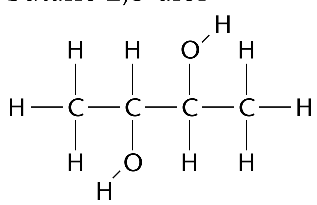
(LB p. 121)

1.
   a) 4-methylpantane-1,2-diol
   b) butan-2-ol

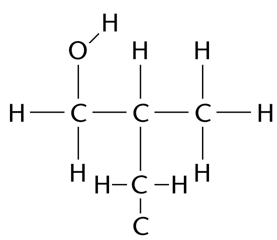
2.
   a) pentan-3-ol



   b) butane-2,3-diol



   c) 2-methylpropan-1-ol

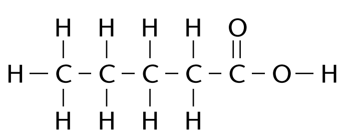


Activity 5.6: Naming carboxylic acids

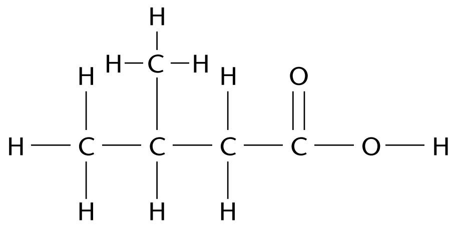
(LB p. 123)

1.
   a) ethanoic acid
   b) propanoic acid

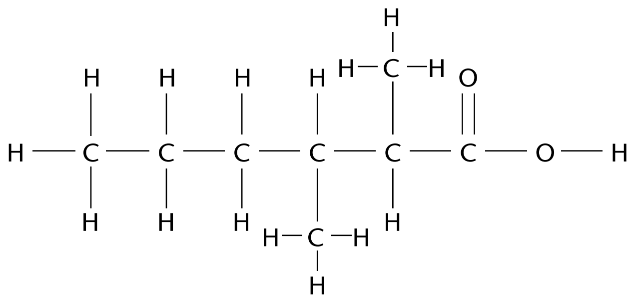
2.
   a) pentanoic acid



b) 3-methylbutanoic acid



c) 2,3-dimethylhexanoic acid



Activity 5.7: Naming aldehydes *(LB p. 125)*

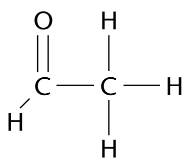
1.

a) 4,5-dimethylhexanal

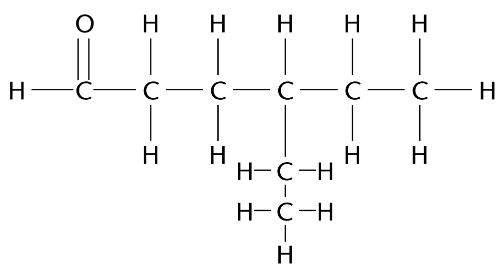
b) methanal

2.

a)



b) 4-ethylhexanal



Activity 5.8: Naming ketones *(LB p. 126)*

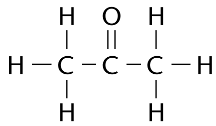
1.

a) butan-2-one

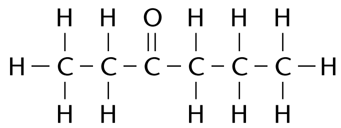
b) pentan-3-one

2.

a) Propanone



b) Hexan-3-one



Activity 5.9: Naming esters *(LB p. 128)*

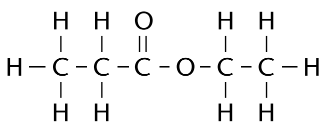
1.

a) pentyl methanoate

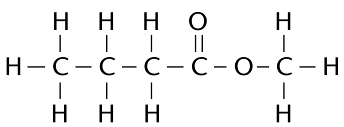
b) butyl hexanoate

2.

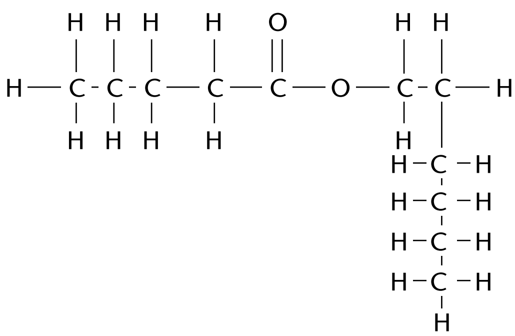
a) ethyl propanoate



b) methyl butanoate



c) hexyl pentanoate



Activity 5.10: Effect of intermolecular forces on physical properties *(LB p. 133)*

1.

a) The difference in boiling points between hex-1-ene and propanoic acid is due to the strength in intermolecular forces. Propanoic acid contains strong hydrogen bond and hex-1-ene comprised of weak London forces. More energy is required to overcome the hydrogen bonds in propanoic acid. The stronger the intermolecular force the higher the boiling.

b) Water contains the strongest intermolecular force (hydrogen bond) and propanone contains dipole-dipole forces, which are weaker than hydrogen bond. The stronger the intermolecular force the higher the boiling.

2.

a) A = London forces

B = Hydrogen bond

C = Hydrogen bond

b) A has only induced-dipole forces (weak van der Waals forces). B has hydrogen bonding. Since hydrogen bonding is a stronger intermolecular force than van der Waals forces, more energy is required to separate the molecules of ethanol than the molecules of ethane. Thus, ethanol has a higher boiling point than ethane.

c) Both B and C undergo hydrogen bonding. However, the hydrogen bonding in C (carbonyl and hydroxyl group) is stronger than that of B (hydroxyl group). This is because C forms a hydrogen bonding dimer (as shown below), while B forms only single hydrogen bonds. Thus, C has a higher boiling point than B.

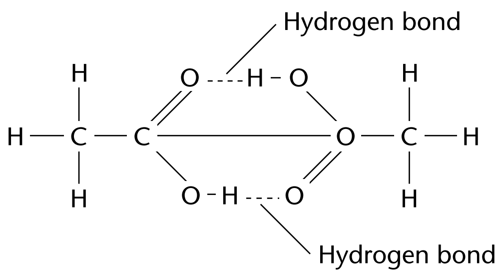
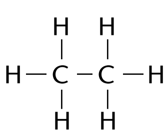


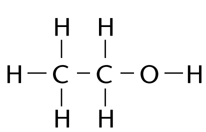
Figure 1: A carboxylic acid hydrogen bonding dimer.

d)

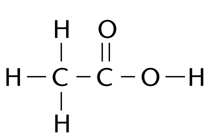
A.



B.

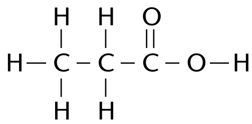


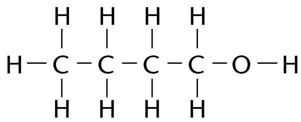
C.



3.

a)

(i) 

(ii) 

b) Both compounds have the same molecular mass, but propanoic acid has two sites for hydrogen bonding (can form a hydrogen bonding dimer), while butan-1-ol has only one. So butan-1-ol has weaker intermolecular forces and will go into the vapour phase easier than propanoic acid. Butan-1-ol therefore has a higher vapour pressure than propanoic acid.

Activity 5.11: Physical properties, chain length and branched groups *(LB p. 135)*

1.

a)

(i) Butane and but-1-ene

(ii) Pentane, Hexane, Pent-1-ene and Hex-1-ene

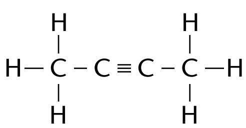
b)

(i) As the molar mass of an alkane increases so does the boiling point.

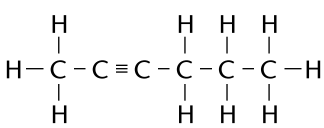
(ii) Van der Waals intermolecular forces increase as chain length increases.

2.

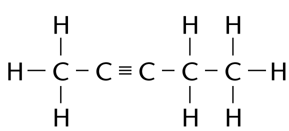
a) But-2-yne



b) Hex-2-yne



c) Pent-2-yne

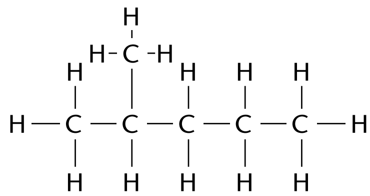


d) Hex-2-yne (The stronger the intermolecular forces (London forces) the more the substance will resist flowing (i.e. the higher the viscosity).

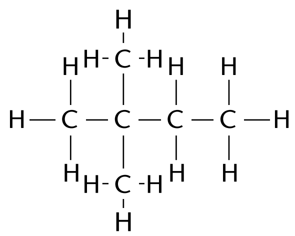
3.

a)

(i) 2-methylpentane

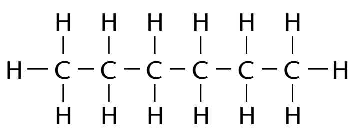


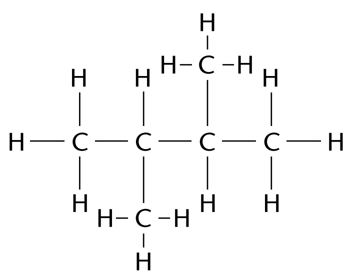
(ii) 2,2-dimethylbutane

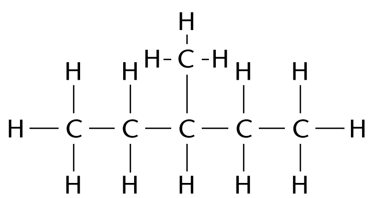


b) 3-methylpentane; 2,3-dimethylbutane; hexane

c)





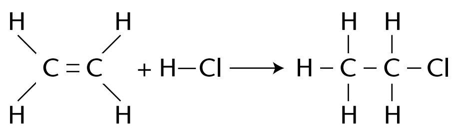


Compounds	Melting point
hexane	–30 °C
3-methylpentane	–95 °C
2,3-dimethylbutane	–118 °C

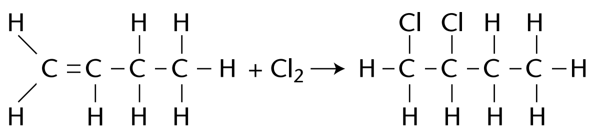
d) Straight chains always have higher boiling points than the equivalent molecule with branched chains. This is because the molecules with straight chains have a larger surface area that allows close contact. Branched chains have a lower boiling point due to a smaller area of contact. The molecules are more compact and cannot get too close together, resulting in fewer places for the van der Waals forces to act.

Activity 5.12: Addition reactions

(LB p. 140)

1. 

2.

a) 

b) Chlorination

c) Saturated-it contain a double bond between the carbon atoms

d) Alkene

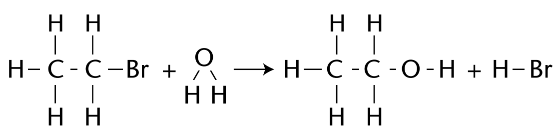
Activity 5.12: Substitution reaction

(LB p. 140)

1.

a) A substitution reaction is a reaction between molecules where an atom (or a group of atoms) replaces a current atom in the original molecule. For example, a hydrogen atom might get kicked off so that a different atom can be put on.

b) WX + YZ → WY + XZ OR WX + YZ → WZ + XY

2. 

Review activity

(LB p. 144)

1.

a) Alkene

b) Hydroxyl group

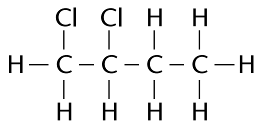
c) Carboxylic acids

d) Ethanoic acid

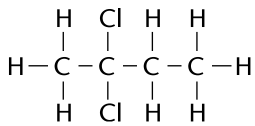
e) Ethanol

2.

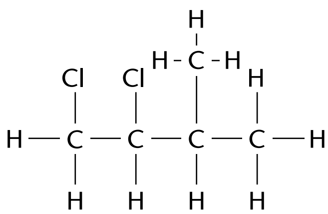
a) 1,2-dichlorobutane



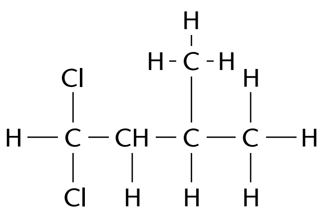
b) 2,2-dichlorobutane



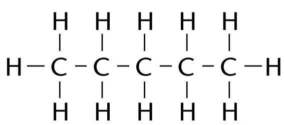
c) 1,2-dichloro-3-methylbutane



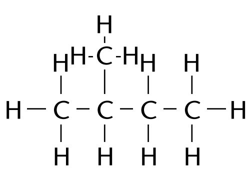
d) 1,1-dichloro-3-methylbutane

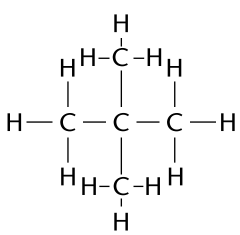


3. 1,2-dichlorobutane

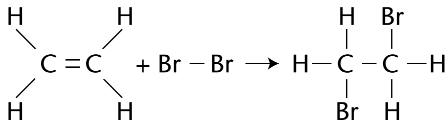


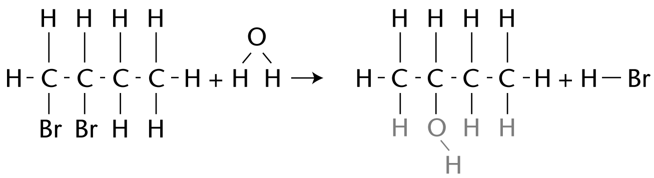
4.



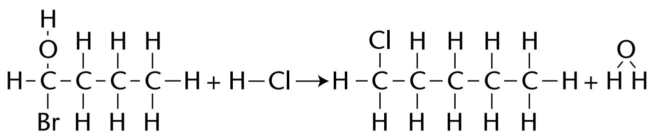


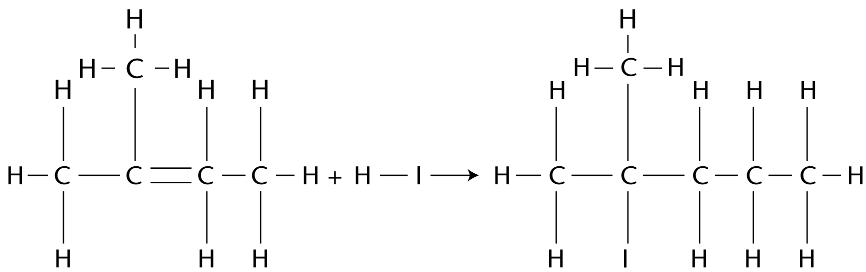
5.

a) 

b) 

c)

(i) 

(ii) 

6.

a)

(i)

1.	ethane
2.	ethane
3.	ethane
4.	ethane
5.	ethane

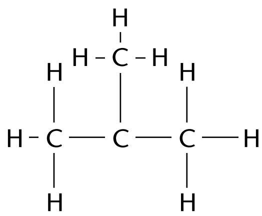
(ii)

6.	alcohol
7.	alcohol
8.	alcohol
9.	alcohol
10.	alcohol

b) Methane, ethane, propane, butane and pentane

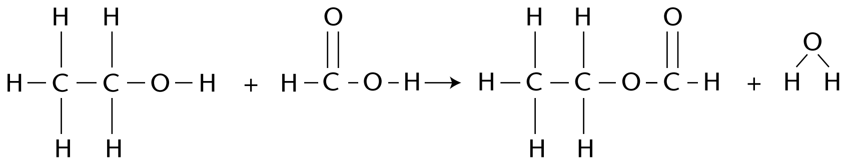
c) The strength in intermolecular forces. The compounds all contains London forces. The differences are due to molar masses.

d) 2-methylpropane



e) ethanol

f)



Ethanol Methanoic acid Ethyl Methanoate Water

7.

a) aldehyde

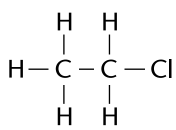
b) 4,4-dibromoprop-1-yne

c) methyl ethanoate

8.

a) $C_2H_6 + Cl_2 \rightarrow C_2H_5Cl + HCl$

b)



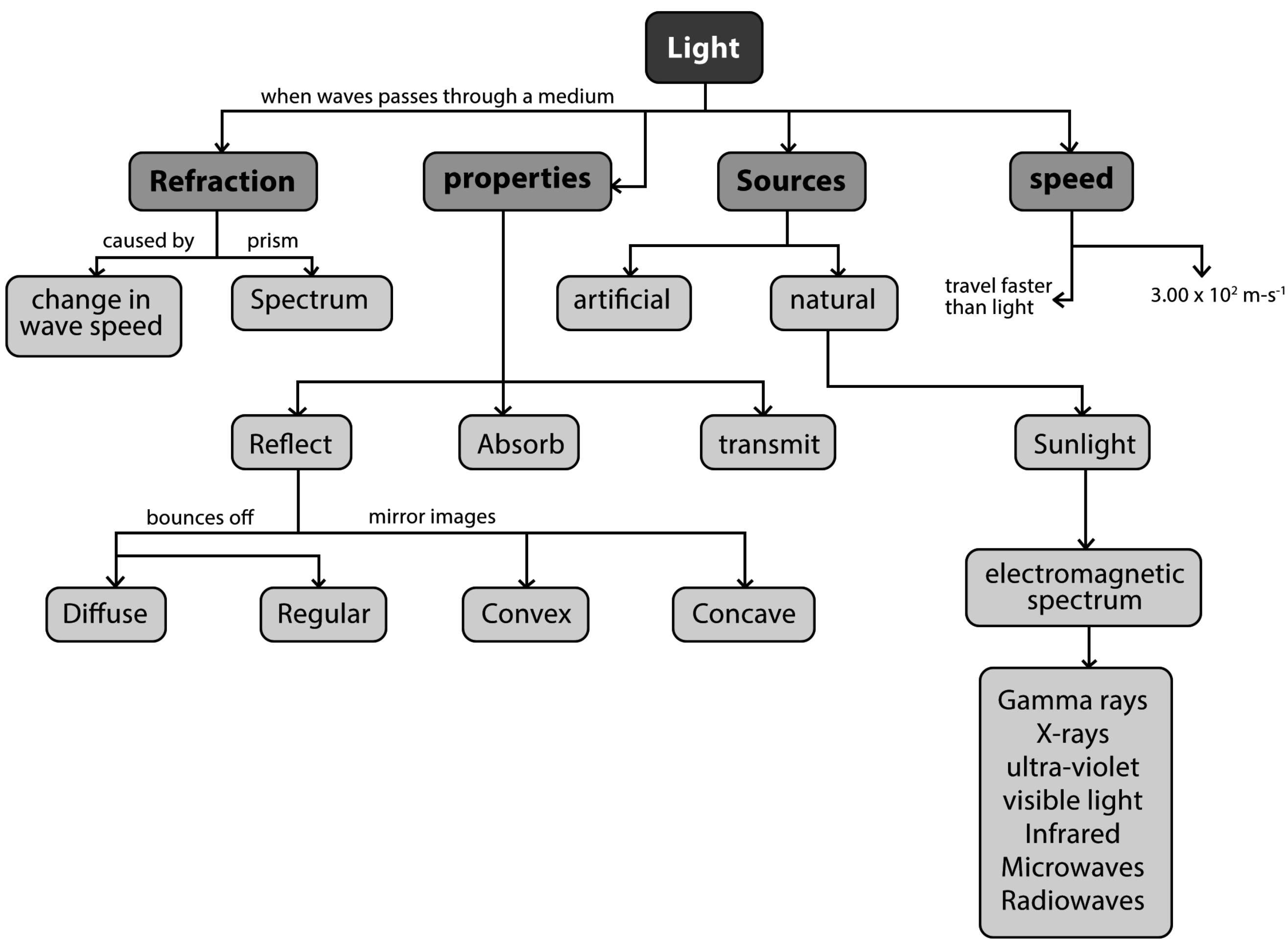
c) substitution reaction

6 Waves, sound and light

CHAPTER OVERVIEW

Light plays a central role in science, technology and culture. The study of light and electromagnetism is fundamental to the evolution of essentially all modern science. Light-based technologies have already revolutionized medicine and opened up international communication via the Internet, and will continue to underpin the future development of human society. Our ability to see and make sense of the world with our eyes depends on the reflective properties of light. Without reflection, we would only be able to see glowing objects like the sun, light bulbs and computer screens. Light rays travel from a light source and then reflect off an object towards our eyes. They bounce off in two different ways, depending on the quality of the surface (at a microscopic level).

Concept map



Suggested answers

Experiment 6 *(LB p. 150)*

The image is always the same distance behind the mirror as the object is in front of the mirror. The object and image always line up along the same normal line and the image is always upright and the same size as the object. It is also located behind the mirror, as a virtual image. Based on the law of reflection, after the light strikes the mirror, it can be concluded that the angle of incidence equals the angle of reflection and can be measured from the normal to either the incident or reflected ray. Either way, the angle measurement remains the same. When the mirror is placed at eye level, one can see a virtual, upright, and virtual image of the same size as the object no matter what the position of the object is.

1. The law of reflection states that the incident ray, the reflected ray, and the normal to the surface of the mirror (surface) all lie in the same plane. Furthermore, the angle of reflection (is equal to the angle of incidence
2. They are equal
3. The incident ray was aimed along the normal and the reflected ray reflected right back along the normal. This is because you are hitting the mirror at a 90 degree angle to the mirror which causes it to reflect right back. When incident ray is aim directly along the normal, one can see a virtual, upright, and virtual imae of the same size as the object no matter what the position of the object is.
4. There are many places for errors to occur in this experiment.
   - The mirror not being set exactly on the horizontal line drawn, causing it to be on an angle with respect to the normal (no longer perpendicular to each other).
   - The mirror could be tilted too much, causing the reflected angle to be slightly off.
   - When tracing out the reflected ray, you might not be accurate enough.
   - If you didn't aim the incident ray exactly at the vertex.
   - If you made errors when measuring the angles with the protractor (not measuring accurately)
5. When playing Billiards (pool), one often uses the sides of the table to bounce the ball off to either hit another ball or to sink a ball. If the player understands that the angle of incidence equals the angle of reflection, then they will know where they must aim along the sides in order to get that symmetrical reflection and hit the desired target.
6. Hockey uses this reflection rule when one uses the boards to pass the puck to a teammate. Basketball uses this rule when bounce passing the ball to a teammate, or when using the back boards when getting a basket. Squash uses this rule when players hit the squash ball at the wall to the opposing challenger. There are many other examples, but overall, it would be any sport that requires you to use a wall to bounce a ball off.

Activity 6.1 (Multiple choice questions) *(LB p. 153)*

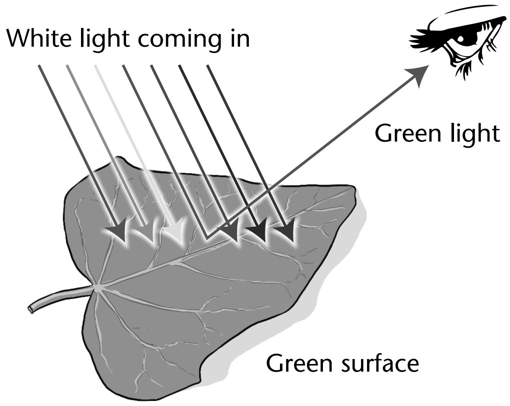
1. B	2. A	3. D	4. A	5. B
6. A	7. B	8. B	9. A	10. C

Activity 6.2 *(LB p. 154)*

The object absorbs all colour from luminous objects and reflect its colour. You see an object when reflected light enters your eyes. The colour of light that bounces off an object gives the object its colour.

Example

The green leaf absorbs all the colours except green which it reflects back into our eyes. We see a green leaf as green light is reflected and the other colours are absorbed by the leaf's surface.



Experiment 6: Formal experiment *(LB p. 157)*

Trial	Angle	Angle of refraction	Angle of emergence
1	40°	25,40°	40°
2	50°	30,72°	50°
3	60°	35,26°	60°

1. Refraction is the bending of light when it passes from one medium to another.
2. Zero
3. Optical density refers to the ability of a medium to change the path of light.
4. When the light beam (ray) pass through glass into air it is refracted and the refracted beam (ray) is bent away from the normal.

   OR

   When the beam moves from glass into air , its path is bent away from the normal
5. No

6. Refractive index of water is 1,33 >1
7. Angle of refraction depends on the angle of incidence and the refractive index.

Discussion and conclusion

1. Angle of incidence = Angle of emergence
2. Incident ray is parallel to the emergent ray
3. Angle of refraction is less than angle of incidence
4. With the increase in angle of incidence, the angle of refraction increases.

Activity 6.3

(LB p. 160)

1. The pencil seems to be bending. The phenomenon is called refraction
2.
   2.1 When light ray does not pass through image

   2.2 When the speed of light ray is changing at a boundary
3. Sir Isaac Newton discovered that white light is actually composed of colors. Prior this discovery, which he proved through experimentation with prism, it was believed that white light was the only purest form of light
4.
   4.1 a – Angle of incident

   c – Angle of refraction

   b – Angle of reflection

   4.2 Relationships in angles mentioned above

   The ratio of the sines of the angles of incidence and refraction is equivalent to the ratio of phase velocities in the two media, or equivalent to the reciprocal of the ratio of the indices of refraction.

   4.3 If a gradually increases b will also increase and c will decrease.

Activity 6.4

(LB p. 165)

1. It causes by both reflection and refraction because the light is refracted when entering a droplet of water, then reflected inside on the back of the droplet and refracted again when leaving it.
2. Reflection and refraction
3. Spectrum
4. Red, Orange, Yellow, Green, Blue, Indigo and Violet

Activity 6.5

(LB p. 178)

Type of radiation	Effect on living tissue	Used for…
Gamma rays	High doses can kill living cells. Lower doses can cause cancer in cells.	Treating tumours. Sterilising hospital equipment.
X-rays	High doses can kill living cells. Lower doese can cause cancer.	Creating images of the inside of the body
Ultraviolet	High doses can kill living cells. Lower doese can cause cancer.	Communication RADAR
Visible light	Activates sensitive cells in the retina.	Seeing Optical fibres and communications
Infrared	Causes burning of tissues	Remote controls and thermal imaging
Microwaves	Heating of water in tissues can cause burning	Satellite communication. Cooking
Radio waves	Probably none	Communication RADAR

Activity 6.6 *(LB p. 179)*

1. NB: Learner own responses. Here are some examples.

Time	Activity	Type of EM wave	Produced by
05:30	Switched on the lights at home.	Visible Light	Light bulbs
06:30	Checked email on my laptop using a wireless network.	Radio	Wireless router.
07:00	Taking a shower (solar geyser)	UV	Sun
08:00	Eating breakfast (warming food)	Microwave	Microwave oven
09:00	Watch the news	Radio waves	Satellite
10:00	Listen to my favourite radio station	Radio waves	Radio
11:00	Take a taxi to the mall and the driver is stopped by the traffic officer for speeding	UV/radio waves	Radar speed gun
12:00	Access free WIFI at the Mall	Microwaves	Router

2. Electromagnetic wave is a changing magnetic and electric field mutually perpendicular to each other and the direction of propagation of the wave.

Activity 6.7 *(LB p. 182)*

1. $E = \frac{hc}{\lambda}$

$E = \frac{6,63 \times 10^{-34} \times 3,0 \times 10^{8}}{496,36 \times 10^{-9}}$

$E = 4,01 \times 10^{-19}$ J

2. $E = hf$

$E = 6,63 \times 10^{-34} \times 5,76 \times 10^{14}$

$E = 3,82 \times 10^{-19}$ J

3.

a) $E = hf$

$E = 6,63 \times 10^{-34} \times 7,25 \times 10^{12}$

$E = 4,81 \times 10^{-21}$ J

b) $E = 4,81 \times 10^{-21} \text{ J} \times \frac{1 \text{ kJ}}{1000 \text{ J}} = 4,81 \times 10^{-24}$ kJ

$E = 4,81 \times 10^{-24}$ kJ

c) No, the frequency of the emitted atom falls outside the visible light frequency range which is ($4,3 \times 10^{14} - 7,5 \times 10^{17}$ Hz).

4. $E = \frac{hc}{\lambda}$

$3.36 \text{ x } 10^{-19} = \frac{6,63 \times 10^{-34} \times 3,0 \times 10^{8}}{\lambda}$

$\lambda = 591,96$ nm

5.

a) $c = f\lambda$

$3,0 \times 10^8 = 6,26 \times 10^{14} \times \lambda$

$\lambda = 4,79 \times 10^{-7}$ nm

b) $E = hf$

$E = 6,63 \times 10^{-34} \times 6,26 \times 10^{14}$

$E = 4,15 \times 10^{-19}$ J

6. $E = \frac{hc}{\lambda}$

$$E = \frac{6,63 \times 10^{-34} \times 3,0 \times 10^8}{11,3 \times 10^{-9}}$$

$E = 1,76 \times 10^{-17}$ J

Review activity

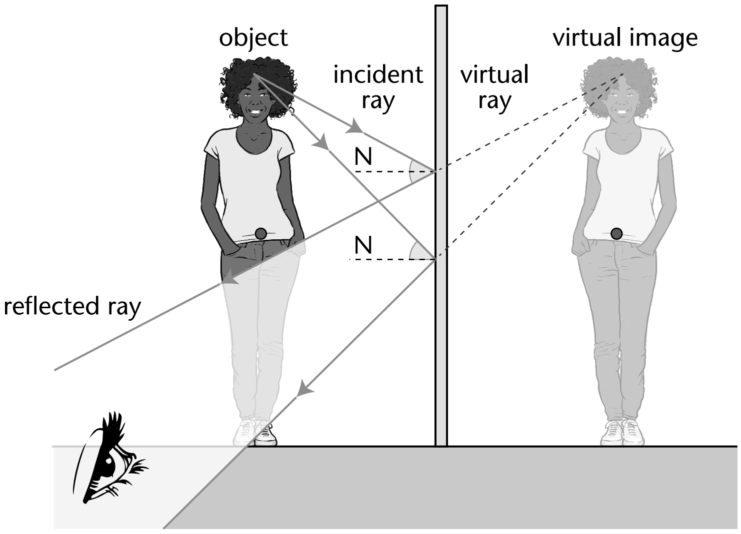
(LB p. 184)

Waves, sound and light quiz

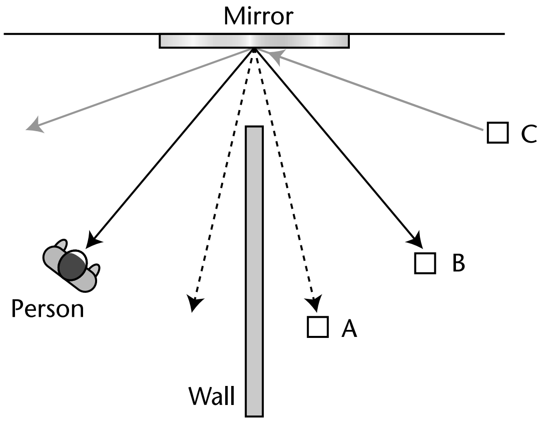
1. Critical angle is an angle of incidence when the angle of refraction is equal to 90°. At any angle of incidence greater than the critical angle, the light cannot pass through the surface - it is all reflected.
2. Total internal reflection is the complete reflection of a light ray reaching an interface with a less dense medium when the angle of incidence exceeds the critical angle.
3. Reflection of light by diamond; endoscopes; optical fibres; automotive rain sensor.
4. Gamma rays
5. 3×10^8 $m \cdot s^{-1}$
6. Decreases
7. Long wavelength
8. Ionising radiation
9. Gamma rays
10. Microwaves and infrared
11. Visible light
12. Gamma, x-rays and ultraviolet region
13. Sunburn; inflammatory reaction of the eyes; skin cancer
14. used in medicine to treat internal organs; kill cancer cells; sterilise medical equipment's
15. Electromagnetic radiation

Chapter questions

1. The light comes in and gets reflected. We know from the law of reflection that the angle of incidence equals the angle of reflection $\theta_i = \theta_r$, so we know that the direction the light is traveling changes, thus the velocity, a vector, must be changing. The speed of light does not change because it continues to travel in air.Does light actually pass through the position of the image formed by a plane mirror? Explain.
2. No, the image is a virtual image. The image is formed because you perceive that light is coming from behind the mirror.
3. The image is formed from a point where you perceive the light to be originating from, thus even though it seems as if the light is coming from behind the mirror, it is actually coming from in front of the mirror and reflecting back.
4. The mirror only has to be 1/2 the size as the person because of the reflection of the rays off of the mirror.



5. The only object that the person can see is object B. This comes from the fact that the angle of incidence equals the angle of reflection (as measured from the normal to the mirror, in this case the wall represents the normal)

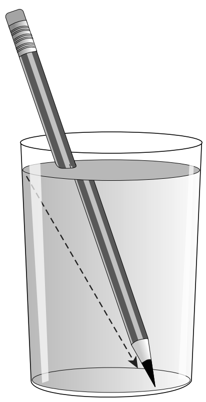


6. Yes, we know that the velocity of the light must change because the direction changed, also it can be noted that the red light travels faster than the blue light. Both are slowed down in the glass, but the red light is slowed down less (not for memorisation)
7. The image must be virtual since the rays do not travel through the spot where the image is formed. The light rays reaching your eye can be traced back to the point where they appear to be coming from, but don't because the rays have been bent at the boundary between the water and the air.
8. The refracted ray will be bent towards the normal since the ray is passing from a less dense material, water with an index of refraction of 1,.33, to a more dense medium, glass, with an index of refraction of 1,.5. Is reflection or refraction responsible for the separation of colours in a rainbow? Explain.
9. No, a near-sighted person has trouble seeing objects far away because the lens cannot focus correctly.
10. The convex lens would be used, opposite from the lens used for near sightedness.
11. Microscopes produce magnified virtual image

Home experiments

(LB p. 185)

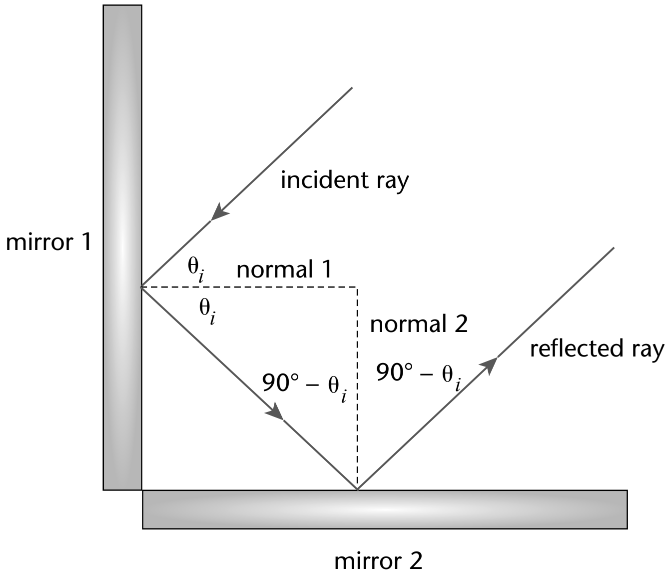
1.



1.1 the objects appear to be smaller.

1.2 from the side they appear to be longer. (i.e. the width of the objects seem to increased).

2.

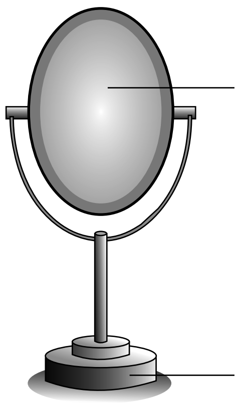


2.1 4 images

2.2 The number of images on increases at an angle of 500

2.3 The line of sight principle suggests that in order to view an image of an object in a mirror, a person must sight along a line at the image of the object. When sighting along such a line, light from the object reflects off the mirror according to the law of reflection and travels to the person's eye. This process was discussed and explained earlier in this lesson. One useful tool that is frequently used to depict this idea is known as a ray diagram. A **ray diagram** is a diagram that traces the path that light takes in order for a person to view a point on the image of an object. On the diagram, rays (lines with arrows) are drawn for the incident ray and the reflected ray. Complex objects such as people are often represented by stick figures or arrows. In such cases it is customary to draw rays for the extreme positions of such objects.

3.

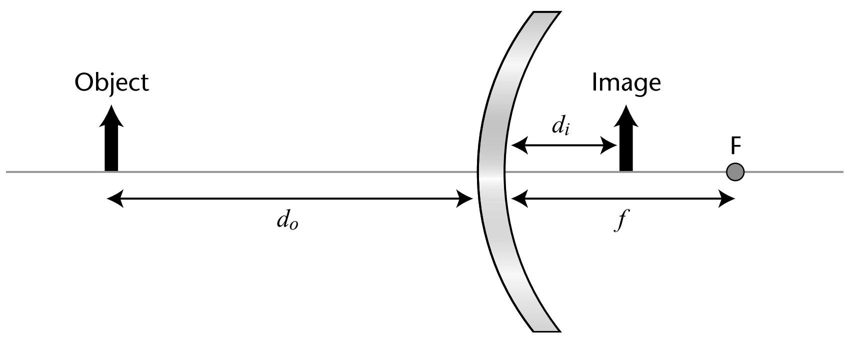


3.1 A concave mirror, or converging mirror, has a reflecting surface that bulges inward (away from the incident light). Concave mirrors reflect light inward to one focal point. They are used to focus light.

3.2 A concave reflector while moving an object away from reflector surface towards its focal point. I understand that when the object is at focal point, no virtual image is formed since all reflected rays are parallel.

4. a) The real height will be shorter than what appears on the mirror.

b) $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$; $M = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$



Example

A 4,0-cm tall light bulb is placed a distance of 35,5 cm from a convex mirror having a focal length of –12,2 cm. Determine the image distance and the image size.

Like all problems in physics, begin by the identification of the known information.

$h_o = 4,0$ cm $\quad d_o = 35,5$ cm $\quad f = -12,2$ cm

Next identify the unknown quantities that you wish to solve for.

$d_i = ?$ $h_i = ?$

To determine the image distance (d_i), the mirror equation will have to be used. The following lines represent the solution to the image distance; substitutions and algebraic steps are shown.

Calculations for h_i

$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

$\frac{1}{-12,2 \text{ cm}} = \frac{1}{35,5 \text{ cm}} + \frac{1}{d_i}$

$-0,0820 \text{ cm} - 1 = 0,0282 \text{ cm} - 1 + \frac{1}{d_i}$

$-0,110 \text{ cm} - 1 = \frac{1}{d_i}$

$d_i = -9,08 \text{ cm}$

$\frac{h_i}{h_o} = -\frac{d_i}{d_o}$

$\frac{h_i}{4,0 \text{ cm}} = \frac{-9,08 \text{ cm}}{35,5 \text{ cm}}$

$h_i = -(4,0 \text{ cm}) \times \frac{-9,08 \text{ cm}}{35,5 \text{ cm}}$

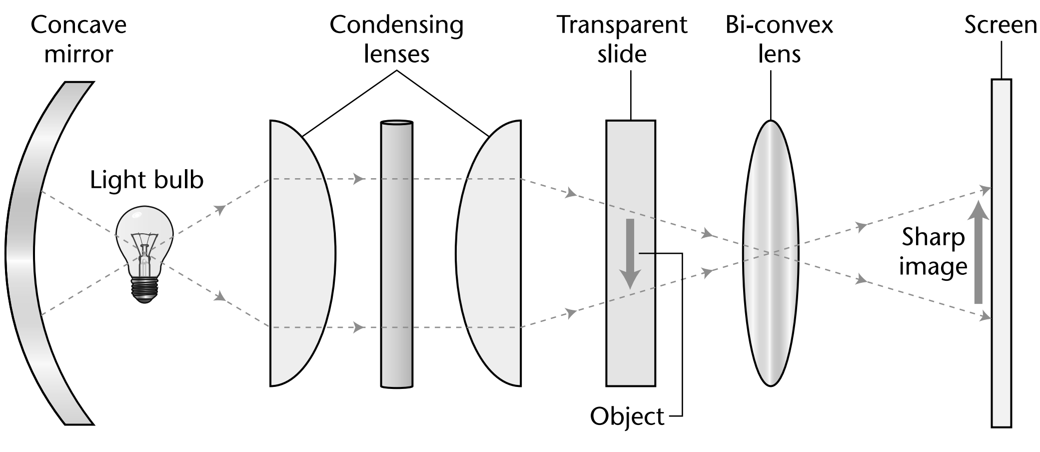
$h_i = 1,02 \text{ cm}$

5.

a) Both the lenses and mirrors

b) The light of the lamp travels between the two mirrors; the second mirror eventually reflects the transparency with information. The lens used in overhead projector is called the 'Fresnel lens', the concept here is the optic works of a microscope and telescope. These lenses are circular and focuses the light in one direction, here to an area of a reflecting mirror, then this mirror reflects the document on screen.

c)

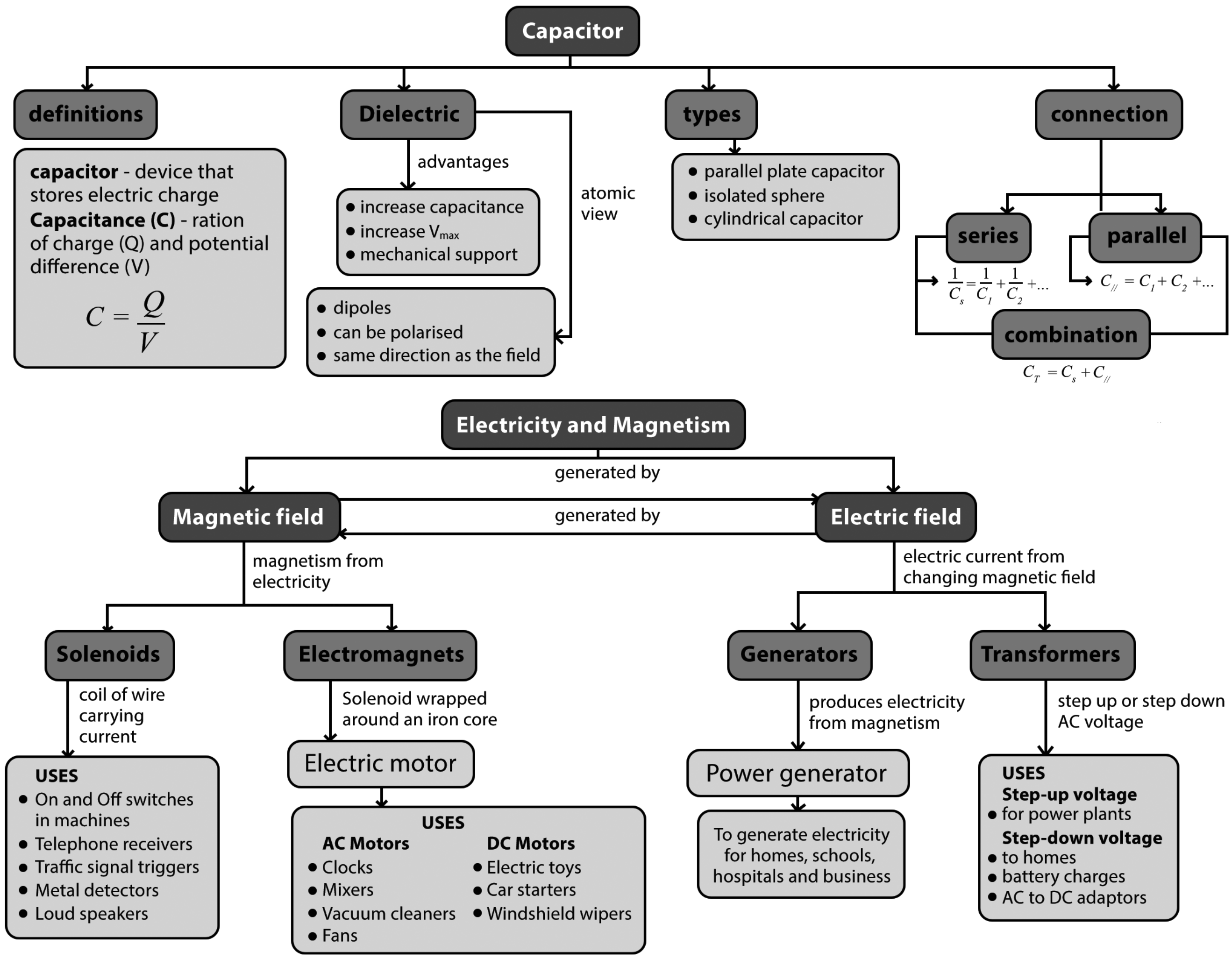


7 Electricity and magnetism

CHAPTER OVERVIEW

The study of capacitors, electromagnetism, electrical circuits, and transformers is essential to understand the technology that uses electricity in the real-world. We rely on electric forces, electricity and electrical appliances to make many things possible in our daily lives.

Concept map



Suggested answers

Activity 7.1: Capacitance *(LB p. 190)*

1. The capacitance of a capacitor is the ratio of the absolute magnitude of the charge on either conductor, to the resulting potential difference, when the conductors have equal and opposite charges.

2. A

3. $C = \frac{Q}{V}$

   $C = \frac{1,25 \times 10^{-6}}{11,3}$

   $C = 1,11 \times 10^{-7}$ F

4. $C = \frac{Q}{V}$

   $7,28 \times 10^{-6} = \frac{Q}{25}$

   $Q = 1,82 \times 10^{-4}\ C = 182\ \mu C$

5. $C = \frac{Q}{V}$

   $4 \times 10^{-6} = \frac{Q}{12}$

   $Q = 4,8 \times 10^{-5}$ C

Activity 7.2: Capacitance *(LB p. 195)*

1. $C = \frac{\varepsilon_0 A}{d}$

   $C = \frac{(8,85 \times 10^{-12})(2 \times 10^{-4})}{1 \times 10^{-3}}$

   $C = 1,77 \times 10^{-12}\ \text{F} = 1,77\ \text{pF}$

2.

   2.1. $C = \frac{\varepsilon_0 A}{d}$

   $C = \frac{(8,85 \times 10^{-12})(2)}{(5 \times 10^{-3})}$

   $C = 3,54 \times 10^{-9}\ \text{F} = 3,54\ \text{nF}$

   2.2. $C = \frac{Q}{V}$

   $3,54 \times 10^{-9} = \frac{Q}{100}$

   $Q = 3,54 \times 10^{-7}$ C

3.

   3.1. $C = \frac{\varepsilon_0 A}{d}$

   $C = \frac{(8,85 \times 10^{-12})(12,2 \times 10^{-4})}{(3,28 \times 10^{-3})}$

   $C = 3,29 \times 10^{-12}\ \text{F} = 3,29\ \text{pF}$

3.2. $C = \frac{Q}{V}$

$$3,29 \times 10^{-12} = \frac{0,435 \times 10^{-9}}{V}$$

$$V = 132,2 \text{ V}$$

4.

4.1. $C = \frac{Q}{V}$

$$5 \times 10^{-12} = \frac{0,2 \times 10^{-6}}{V}$$

$$V = 40\,000 \text{ V} = 40 \text{ kV}$$

4.2. $C = \frac{\varepsilon_0 A}{d}$

$$5 \times 10^{-12} = \frac{(8,85 \times 10^{-12})(A)}{0,6 \times 10^{-3}}$$

$$A = \frac{5 \times 10^{-12} \times 0,6 \times 10^{-3}}{8,85 \times 10^{-12}}$$

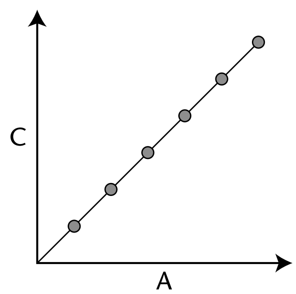
$$A = 3,39 \times 10^{-4} \text{ m}^2 = 3,39 \text{ cm}^2$$

5.

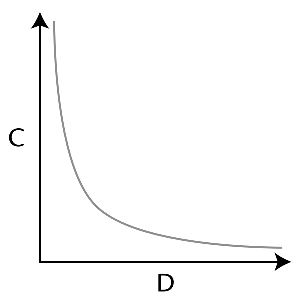
- Separation distance between the plates. The further apart the plates are, the smaller the capacitance.
- Area of the plates. The bigger the area the higher the capacitance.
- Dielectric between the plates. The smaller the dielectric constant of the material used to make the plates, the smaller the capacitance.

6.

6.1.



6.2.



Activity 7.3: Power and Electrical Energy *(LB p. 199)*

1. $P = VI$

   $P = (240)(9)$

   $P = 2\,160 \text{ W}$

2. $P = VI$

   $2{,}1 \times 10^3 = (V)(10{,}5)$

   $V = 200 \text{ V}$

3. $P = I^2 R$

   $P = (20)^2(0{,}325)$

   $P = 130 \text{ W}$

4. $P = I^2 R$

   $1 \times 10^3 = I^2(40)$

   $I^2 = 25$

   $I = 5 \text{ A}$

5. $P = I^2 R$

   $100 = (0{,}42)^2 R$

   $R = 566{,}89\ \Omega$

6. $P = \frac{V^2}{R}$

   $P = \frac{240^2}{800}$

   $P = 72 \text{ W}$

7. $P = \frac{V^2}{R}$

   $100 = \frac{(240)^2}{R}$

   $R = 576\ \Omega$

	Series Connection	Parallel Connection
7.1.	$R_T = R_1 + R_2$ $R_T = 576 + 576 = 1152\ \Omega$	$R_T = \frac{R_1 R_2}{R_1 + R_2}$ $R_T = \frac{(576)(576)}{576 + 576} = 288\ \Omega$
7.2.	$P = \frac{V^2}{R}$ $P = \frac{240^2}{1152} = 50 \text{ W}$	$P = \frac{V^2}{R}$ $P = \frac{240^2}{288}$ $P = 200 \text{ W}$

Experiment 8: Memorandum *(LB p. 200)*

Part 1

Result:

Series circuit

Number of light bulbs	Voltage (V)	Current (A)	Power (W)
1	3	0,3	0,90
2	3	0,22	0,66
3	3	0,18	0,54

Result:

Parallel circuit

Number of light bulbs	Voltage (V)	Current (A)	Power (W)
1	3	0,3	0,9
2	3	0,5	1,5
3	3	0,7	2,1

Analysis of the results:

In the first part of the experiment we increased the number of resistor in series so we increased the resistance and so the current decreased then as current decreased the power also decreased (The brightness of the light bulb become weaker as you increase more light bulbs in series). The voltage was kept constant. Here the power decreases as current decreases (Figure 7.1).

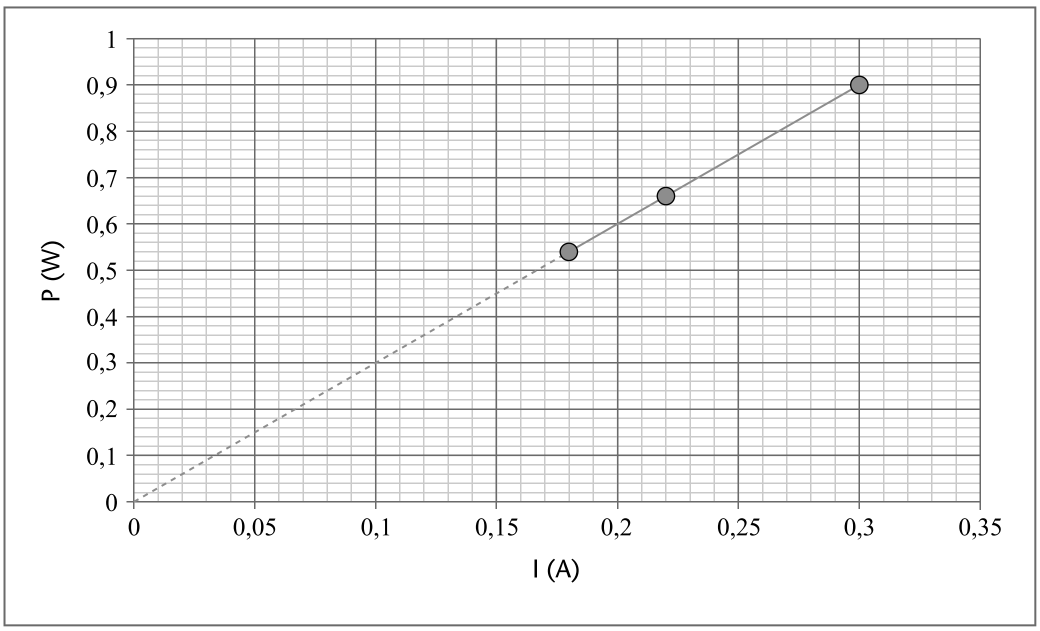


Figure 7.1 Graph of Power vs Current

The graph is an straight line which represent a linear function with the equation

$$\boldsymbol{y = mx + C}$$

$$y = P, x = I \text{ and } m = V = \text{terminal voltage} = \text{constant}$$

Then

$$P = VI$$

$$\boldsymbol{P \propto I}$$

As current decreases power dissipated also decreases.

In the second part of the experiment we connect the light bulbs in parallel and so the resistance decreased so the current in the circuit increased. The voltage was kept constant. The power increased Figure 7.2.

Part 2

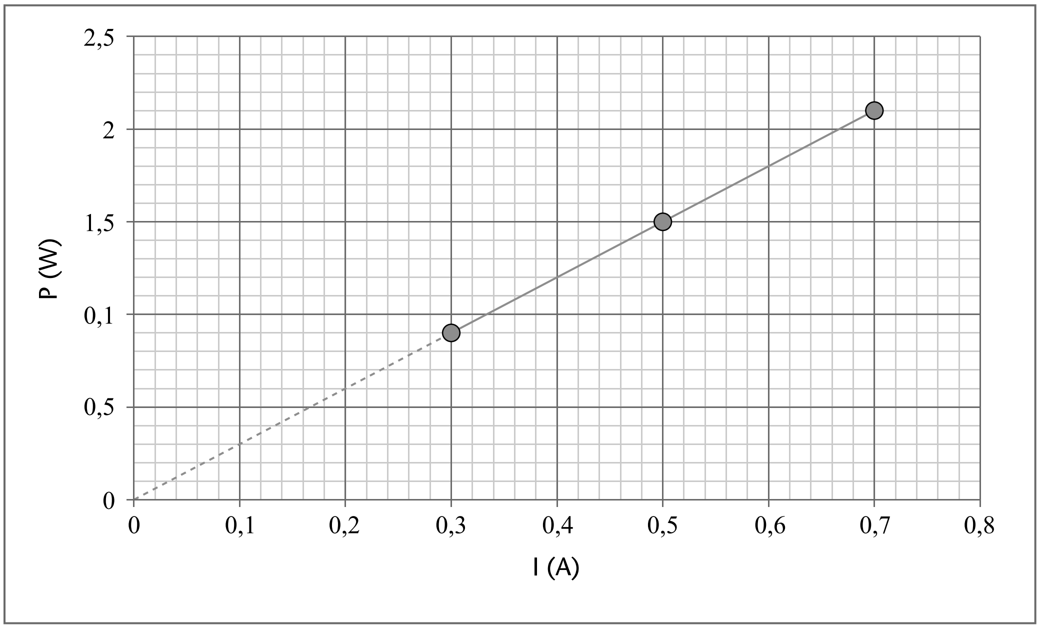


Figure 7.2 Graph of power vs current 2

The graph is an straight line which represent a linear function with the equation

$$\boldsymbol{y = mx + C}$$

$$y = P, x = I \text{ and } m = V = \text{terminal voltage} = \text{constant}$$

Then

$$P = VI$$

$$\boldsymbol{P \propto I}$$

Current increases power dissipated also increases

Conclusions:

In a series circuit as the number of resistors increases the total resistance increases then current decreases and as a result the power dissipated also decreases.

In a parallel circuit as the number of resistors increases the equivalent (effective) resistance decreases the current in the circuit increases and as a result the power dissipated also increases.

Therefore the use of a parallel circuit is more advantageous than a series circuit.

Activity 7.4: Heating effect of electric current *(LB p. 203)*

1.

1.1 $R = \frac{V}{I}$

$R = \frac{240}{12}$

$R = 20\ \Omega$

1.2 $P = VI$

$P = (240)(12)$

$P = 2\ \ 880\ \text{W}$

1.3 $W = I^2Rt$

$W = (12^2)(20)(20 \times 3600)$

$W = 2{,}074 \times 10^8\ \text{J}$

2. $W = I^2Rt$

$W = (5)^2(20)(30)$

$W = 1{,}5 \times 20^4\ \text{J}$

3. $W = I^2Rt$

$W = (15)^2(8)(2 \times 3\ 600)$

$W = 1{,}296 \times 10^7\ \text{J}$

$P = \frac{W}{\Delta t}$

$P = \frac{1{,}296\ \times\ 10^7}{2\ \times\ 3\ 600}$

$P = \frac{1{,}296\ \times\ 10^7}{7\ 200}$

$P = 1{,}8\ \times\ 10^3\ W$

4. $V = \frac{W}{Q}$

$50 = \frac{W}{9600}$

$W = 4{,}8 \times 10^5\ \text{W} = 480\ \text{kW}$

Activity 7.5 *(LB p. 210)*

1. Magnetic flux density is the amount of magnetic flux per unit area of a section that is perpendicular to the direction of flux.

2. $$\begin{aligned} \Phi &= BA \\ \Phi &= B(\pi r^2) \\ \Phi &= (4,9)\left(\pi\left(\frac{0,5 \times 10^{-2}}{2}\right)^2\right) \\ \Phi &= 9,621 \times 10^{-5}\ Wb \end{aligned}$$

3. $$\begin{aligned} \Phi &= BA \\ \Phi &= B(\pi r^2) \\ \Phi &= 2,5 \times \pi \times (3 \times 10^{-2})^2 \\ \Phi &= 7,069 \times 10^{-3}\ \text{Wb} \end{aligned}$$

Activity 7.6 *(LB p. 213)*

1. The emf, ε, induced around a loop of conductor is proportional to the rate of change of the magnetic flux, Φ, through the area, A, of the loop.

2. $$\begin{aligned} \varepsilon &= -N\frac{\Delta\Phi}{\Delta t} \\ \varepsilon &= -\frac{(1200)(0,045 - 0,03)}{0,1} \\ \varepsilon &= -180\ \text{V} \end{aligned}$$

3. $$\begin{aligned} \varepsilon &= -N\frac{\Delta\Phi}{\Delta t} \\ \varepsilon &= -\frac{(850)(0 - 0,015)}{0,25} \\ \varepsilon &= 51\ \text{V} \end{aligned}$$

4. $$\begin{aligned} \varepsilon &= -N\frac{\Delta\Phi}{\Delta t} \\ \varepsilon &= -\frac{(150)(0,075 - 0,05)}{5 \times 10^{-3}} \\ \varepsilon &= -750\ \text{V} \end{aligned}$$

5. $$\begin{aligned} \varepsilon &= -N\frac{\Delta\Phi}{\Delta t} \\ -0,2 &= -100\,\frac{\Delta\Phi}{2,5} \\ \Delta\Phi &= \frac{(-0,2)(2,5)}{-100} \\ \Delta\Phi &= 5 \times 10^{-3}\ \text{Wb} \end{aligned}$$

Activity 7.7 *(LB p. 218)*

1. Emf stands for electromotive force. It is a voltage measured across the terminals of the battery when there is no current in the circuit (or when there is no load in the circuit).

2.
   2.1 The needle in the galvanometer deflects.

   2.2 An emf is induced in the coil of wire, which in turn produces a current which moves the needle.

   2.3 Faraday's law, states that the emf produced around a loop of a conductor is directly proportional to the rate of change of the magnetic flux, Φ, through the area, A, of the loop.

   2.4 There is a greater deflection of the needle.

   2.6
   - Increase the number of windings on the coil
   - Increase the speed at which the magnet is moving relative to the coil
   - Use a stronger magnet.

Activity 7.8 *(LB p. 222)*

1. A transformer is a device used to step up or step down the AC voltage.

2. $\frac{N_p}{N_s} = \frac{V_p}{V_s}$

   $\frac{500}{3000} = \frac{240}{V_s}$

   $V_s = 240 \times \frac{3000}{500}$

   $V_s = 1440 \text{ V} = 1,44 \text{ kV}$

3. $P = VI$

   $150 = 12(I)$

   $I = 12,5\ A$

   $V_1I_1 = V_2I_2$

   $(12,5)(12) = (240)(I_2)$

   $I_2 = 0,625 \text{ A}$

4. $\frac{N_p}{N_s} = \frac{V_p}{V_s} = 2:7$

   $\frac{240}{V_s} = \frac{2}{7}$

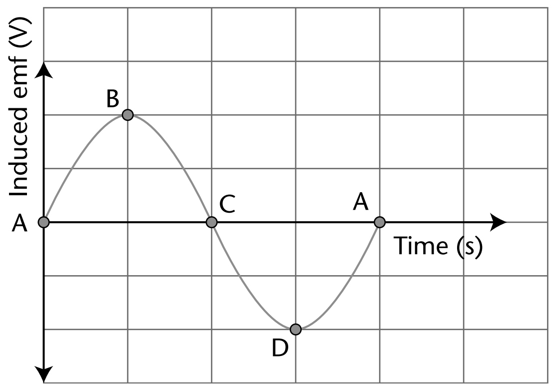
   $V_s = 240 \times \frac{7}{2}$

   $V_s = 840 \text{ V}$

Activity 7.9

(LB p. 228)

1. A generator is a device that converts mechanical energy to electrical energy.
2. Faraday's law of electromagnetic induction.
3. AC generator has slip rings, while DC motor has split rings (commutator).
4. An electric motor is a device that converts electrical energy to mechanical energy.
5.
   5.1 Electromagnetic induction.
   5.2 Electrical energy to mechanical energy.
   5.3 Because its plane is perpendicular to the magnetic field.
   5.4 Clockwise.
6.
   6.1 Faraday's law of electromagnetic induction
   6.2 Provides a sliding contact between coil and conducting wires/ or Ensures free rotation.
   6.3 Graph of induced emf versus time:



   6.4 Increase the speed at which the coil rotates.
   6.5 Split ring (or commutator)

Review activity

(LB p. 232)

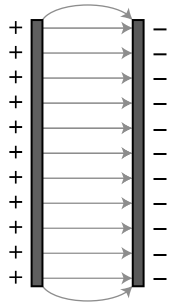
Multiple choice questions

1. A 2. D 3. B 4. C 5. B

Long questions

Capacitance

1.
   1.1 Charge

1.2 

1.3 Capacitor discharges

1.4 $C = \frac{Q}{V}$

$450 \times 10^{-6} = \frac{Q}{1,5}$

$Q = 6,75 \times 10^{-4}$ C

2.

2.1 $C = \frac{\varepsilon_0 A}{d}$

$C = \frac{(8,85 \times 10^{-12})(3 \times 10^{-2} \times 6 \times 10^{-2})}{2 \times 10^{-3}}$

$C = 7,965 \times 10^{-12}\ \text{F} = 7,965\ \text{pF}$

2.2 Doubling the distance decreases the capacitance by the factor of 2.

$$C_{new} = \frac{1}{2} \times (7,965\ \text{pF}) = 3,983\ \text{pF}$$

Electric circuits: Electrical power

1. $P = VI$

   $P = (250)(4)$

   $P = 1\,000\ \text{W} = 1\ \text{kW}$

2. $E = VIt$

   $E = (12)(5)(2 \times 60)$

   $E = 7\,200\ W = 7,2\ kW$

3. $P = \frac{V^2}{R}$

   $P = \frac{240^2}{30}$

   $P = 1\,920\ \text{W} = 1,92\ \text{kW}$

4. Electric kettle, electric heater, hair dryer, toaster, microwave oven… (any three)

5. $W = I^2 Rt$

   $W = (1,5)^2(100)(60)$

   $W = 13\,500\ \text{J} = 13,5\ \text{kJ}$

Electromagnetism: Generators and motors

1.

1.1 AC – alternating current

A separate sling ring connected to each wire

1.2 Increase in peak voltage.

Increase in frequency

1.3 The plane of the coil is parallel to the magnetic field.

1.4 Advantage – less environmental pollution (noise, air…)

Renewable energy source.

Disadvantage: will not operate in the absence of the wind

Many windmills needed to generate sufficient electricity

Transformers

1.

1.1 Electromagnetic induction principle (Faraday's law).

1.2 Faraday's law states that

1.3 Step-down transformer. The primary voltage is too high (240 V) than the required secondary voltage (6 V). A step-down transformer is the one which decreases the voltage to the required secondary voltage.

1.4 $\frac{N_p}{N_s} = \frac{V_s}{V_p}$

$\frac{480}{N_s} = \frac{240}{6}$

$\frac{480}{N_s} = 40$

$N_s = \frac{480}{40} = 12$

2. $\frac{N_p}{N_s} = \frac{V_p}{V_s}$

$\frac{800}{2000} = \frac{160}{V_s}$

$V_s = 160 \times \frac{2\,000}{800}$

$V_s = 400 \text{ V}$

3. $\frac{N_p}{N_s} = \frac{V_p}{V_s}$

$\frac{240}{V_s} = \frac{8}{1}$

$V_s = 240 \times \frac{1}{8}$

$V_s = 30 \text{ V}$

$V_p I_p = V_s I_s$

$(240)(3) = (30)(I_s)$

$I_s = 24 \text{ A}$

4. $$\frac{N_p}{N_s} = \frac{V_p}{V_s} = \frac{12}{1}$$

$$\frac{180}{V_s} = \frac{12}{1}$$

$$V_s = 180 \times \frac{1}{12}$$

$$V_s = 15 \text{ V}$$

$$V_p I_p = V_s I_s$$

$$(180)(4) = (15)(I_s)$$

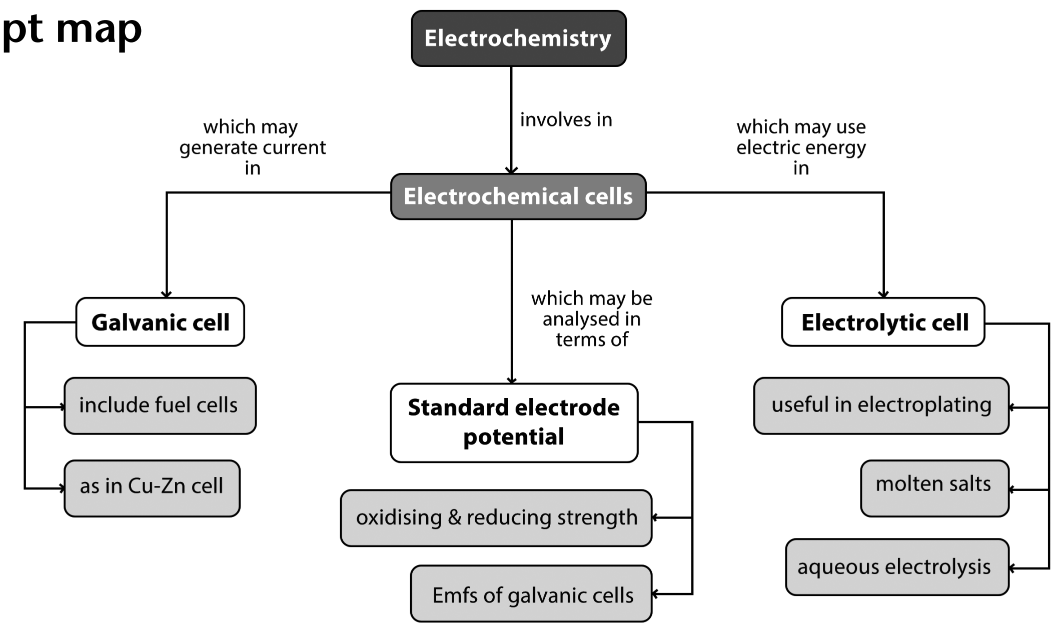
$$I_s = 48 \text{ A}$$

8 Chemical change

CHAPTER OVERVIEW

The importance of electrochemistry is undeniable—we literally cannot live without electrochemistry for proper cell function and transmission of signals through the nervous system. Electrochemistry is also vital in a wide range of important technological applications. For example, batteries are important not only in storing energy for mobile devices and vehicles, but also for load levelling to enable the use of renewable energy conversion technologies. Electrochemistry is involved in the production of materials by electro-refining or electro-deposition as well as the destruction of materials by corrosion

Concept map



Suggested answers

Activity 8.1

(LB p. 238)

1. The oxidation state of Cl atom doesn't change. Hence chlorine ion is a spectator ion.

Species	Oxidation number as a Reactant	Oxidation number as a products
Ca:	0	$x + 2(-1) = 0x = +2$ The oxidation number of Ca in CaCl2 is +2
Zn	$x + 2(-1) = 0x = +2$ Oxidation number of Zn in $ZnCl_2$	0

Zn is reduced. And so the reduction half-reaction is: $Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$

Ca is oxidised, and so the reduction half-reaction is: $Ca(s) \rightarrow Ca^{2+}(aq) + 2e^-$

2. Oxygen is a spectator ion because its oxidation number doesn't change.

Species	Oxidation number as a Reactant	Oxidation number as a products
Al	0	$2x + 3(-2) = 02x = +6x = +3$ The oxidation number of Al in Al_2O_3 is +3
Fe	$2x + 3(-2) = 02x = +6x = +3$ The oxidation number of Fe in Fe_2O_3 is +3	0

Fe is reduced. The reduction half-reaction is: $Fe^{3+}(aq) + 3e^- \rightarrow Fe(s)$

Al is oxidised, and so the reduction half-reaction is: $Al(s) \rightarrow Al^{3+}(aq) + 3e^-$

3. NO_3^- ion is a spectator ion because is oxidation state doesn't change.

Species	Oxidation number as a Reactant	Oxidation number as a products
Ni	0	$x + 2(-1) = 0x = +2$ Oxidation number of Ni in $Ni(NO_3)_2$ is +2
Cu	$x + 2(-1) = 0x = +2$	0

Cu is reduced. Reduction half reaction is: $\text{Cu}^{2+}(aq) + 2e^- \rightarrow \text{Cu}(s)$

Ni is oxidised, and so the reduction half-reaction is: $\text{Ni}(s) \rightarrow \text{Ni}^{2+}(aq) + 2e^-$

4. NO_3^- is a spectator ion

Species	Oxidation number as a Reactant	Oxidation number as a products
Ca	0	$x + 2(-1) = 0x = +2$
H	$x + (-1) = 0x = +1$	0

H is reduced. Reduction half-reaction is: $2\text{H}^+ + 2e^- \rightarrow \text{H}_2$

Ca is oxidised, and so the reduction half-reaction is: $\text{Ca}(s) \rightarrow \text{Ca}^{2+}(aq) + 2e^-$

Experiment 11 (Follow-up questions)

(LB p. 244)

1. The blue litmus paper turns red and there after it is bleached white
2. Copper deposit is produced at the cathode (negative electrode) and chlorine gas is produced at the anode (positive electrode).
3.
   3.1 $\text{Cu}^{2+}(aq) + 2e^- \rightarrow \text{Cu}(s)$

   3.2 $2\text{Cl}^-(aq) \rightarrow \text{Cl}_2(g) + 2e^-$
4. $\text{Cu}^{2+}(aq) + 2e^- \rightarrow \text{Cu}(s)$

   $2\text{Cl}^-(aq) \rightarrow \text{Cl}_2(g) + 2e^-$

   Nett : $\text{Cu}^{2+}(aq) + 2\text{Cl}^-(aq) \rightarrow \text{Cu}(s) + \text{Cl}_2(g)$

5.

5.1 Anode is positive

5.2 Cathode is negative

Activity 8.2 *(LB p. 245)*

1.

1.1 Electrolyte is a solution that can conduct electricity.

1.2 The electrolytic cell is an electrochemical cell that converts electrical energy to chemical energy. This process is a nonspontaneous process.

1.3 Electrolysis is process by which electric current is passed through ionic substance to effect a chemical change.

2. The transfer of electrons from one species to the other resulting in the change in oxidation number.

3.

3.1 At the anode electrode. The gas produced is chlorine.

3.2 $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

3.3 $Na^+(aq) + e^- \rightarrow Na(s)$

3.4 $2Na^+(aq) + 2Cl^- \rightarrow 2Na(s) + Cl_2(g)$

4. The function of a power source is to provide the electric energy that will drive the nonspontaneous reaction of decomposing the molten sodium chloride.

5.

5.1 Gas A is the chlorine gas, and deposit B is the copper deposit.

5.2 Anode.

5.2.1 $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

5.2.2 $2Cl^- \rightarrow Cl_2 + 2e^-$

5.3 $Cu^{2+}(aq) + 2Cl^-(aq) \rightarrow Cu(s) + Cl_2(g)$

Activity 8.3 *(LB p. 248)*

	Reaction A	Reaction B
1.1	Oxidation half-reaction takes place at the anode electrode. Zn is oxidized to Zn^2 + ions. Therefore, Zn electrode is the anode electrode.	Cu is oxidized to Cu^2+. There the copper electrode is the anode electrode.
1.2	Cu electrode is the cathode	Fe electrode is the cathode electrode
1.3	$E^0_{cell} = E^0_{cathode} - E^0_{anode}$ $E^0_{cell} = (0,34) - (0,76)$ $E^0_{cell} = 1,1\ V$	$E^0_{cell} = E^0_{cathode} - E^0_{anode}$ $E^0_{cell} = 0,77 - (0,34)$ $E^0_{cell} = 0,43\ V$

2. $E^0_{cell} = E^0_{cathode} - E^0_{anode}$

$1{,}6 = E^0_{cathode} - (-2{,}36)$

$E^0_{cathode} = -0{,}76\ V$

Therefore the electrode used at the cathode is Zn.

Activity 8.4 *(LB p. 250)*

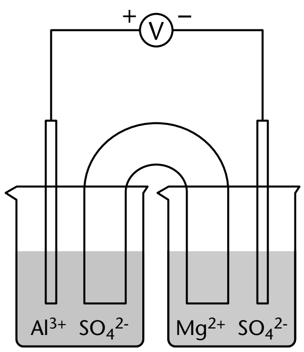
1.

1.1 $Mg(s)\,|\,Mg^{2+}\,\|\,Al^{3+}(aq)\,|\,Al(s)$

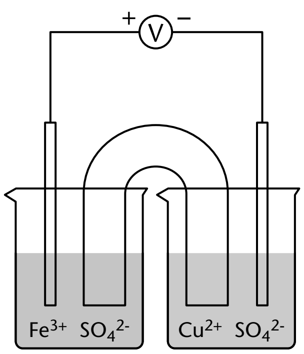
1.2 $Cu(s)\,|\,Cu^{2+}(aq)\,\|\,Fe^{3+}(aq)\,|\,Fe^{2+}(aq)$

2.

2.1



2.2



Experiment 12 (Formal) *(LB p. 244)*

Observations/Results

In the experiment, the Cu^{2+}ions from the **blue copper(II) sulfate** solution were reduced (gained electrons) to copper metal, which was then deposited as a layer on the solid zinc. The zinc atoms were oxidised (lost electrons) to form Zn^{2+} ions in the solution. Zn^{2+} is colourless, therefore the blue solution lost colour.

Conclusion

When a zinc (II) sulfate solution containing a zinc plate is connected by a salt bridge to a copper (II) sulfate solution containing a copper plate, reactions occur in both solutions. The decrease in mass of the zinc plate suggests that the zinc metal electrode has been oxidised to form zinc ions in solution.

The increase in mass of the copper plate suggests that reduction of copper ions has occurred here to produce more copper metal.

Copper ions oxidised Zn to Zn^{2+}. The half reactions and the nett reactions are:

$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^{-}$ (oxidation)

$Cu^{2+}(aq) + 2e^{-} \rightarrow Cu(s)$ (reduction)

Nett: $Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$

Follow up questions

1.
   1.1 zinc electrode
   1.2 copper electrode
2.
   2.1 Anode: $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^{-}$
   2.2 Cathode: $Cu^{2+}(aq) + 2e^{-} \rightarrow Cu(s)$
3. $Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$
4. $\pm 1{,}1$ V
5. The voltmeter needle will deflect in the direction of conventional current, however, the electrons flow in the opposite direction. In this experiment, the electrons will flow from the zinc plate towards the copper plate meaning that Zn electrode is an anode and Cu electrode is a cathode.
6. To keep the solutions electrically neutral and allow the free flow of ions from one cell to another.
7. Oxidation is characterised by an increase in oxidation number.
8. Reduction is characterised by an decrease in oxidation number.
9. Copper ions
10. Zinc

Activity 8.5

(LB p. 247)

1.
   - **Half cells:** Half of the redox reaction occurs at each half cell. Therefore, we can say that in each half-cell a half-reaction is taking place. When the two halves are linked together with a wire and a salt bridge, an electrochemical cell is created.
   - **Electrodes:** an electrode is strip of metal on which the reaction takes place. In a voltaic cell, the oxidation and reduction of metals occurs at the electrodes. When an electrode is oxidized in a solution, it is called an anode and when an electrode is reduced in solution it is called a cathode.
   - **Salt bridge:** The salt bridge is a vital component of any voltaic cell. It is a tube filled with an electrolyte solution. The purpose of the salt bridge is to keep the solutions electrically neutral and allow the free flow of ions from one cell to another. Without the salt bridge, positive and negative charges will build up around the electrodes causing the reaction to stop.

2. Galvanic cell (also known as voltaic cell) is an electrochemical cell that converts chemical energy to electrical energy. The reaction occurs spontaneously. It consists of two separate half-cells.

   Electrolytic cell converts electrical energy into chemical energy. The redox reaction is not spontaneous and electrical energy has to be supplied to initiate the reaction. Both the electrodes are placed in a same container in the solution of molten electrolyte.

3. Oxidation is a half reaction during which the oxidation number a species increases. Reduction is a half reaction categorised by a decrease in oxidation number of a species.

4.
   - 4.1 $x + 2(-2) = 0$

     $x = +4$
   - 4.2 $2x + 3(-2) = 0$

     $2x = +6$

     $x = +3$
   - 4.3 Zn is oxidised.
   - 4.4 $Zn \rightarrow Zn^{2+} + 2e^-$
   - 4.5 $Mn^{4+} + e^- \rightarrow Mn^{3+}$
   - 4.6 $Zn(s) + 2Mn^{4+} \rightarrow Zn^{2+}(aq) + 2Mn^{3+}$

Review activity

(LB p. 257)

Multiple choice questions

1. A	2. D	3. B	4. A	5. C
6. A	7. D	8. A	9. D	

Long questions

1.
   - 1.1 Electrolytic cell
   - 1.2
     - 1.2.1 Cell A
     - 1.2.2 Cell B
   - 1.3
     - 1.3.1 Remains the same.
     - 1.3.2 $Cu \rightarrow Cu^{2+} + 2e^-$
   - 1.4
     - 1.4.1 It contains precious metals.
     - 1.4.2 Consumes large amount of electricity/energy. Depletes coal resources. OR Contributes to global warming. OR Habitats destroyed in mining of coal. OR Contributes to acid rain.

2. A

2.1 $2\ H_2O \rightarrow 2H_2 + O_2$

2.2 Cathode

2.3 H^+ ion.

3.

3.1 Pressure must be 1 atm and a temperature of 25°C or 298 K

3.2 Salt bridge.

3.3 Anode. Hydrogen is a stronger oxidizing agent than magnesium (or the hydrogen half-cell has a higher cell potential than magnesium half-cell).

3.4 $\text{Mg}(s)|\text{Mg}^{2+}(aq)||\text{H}^+(aq);\text{H}_2(g)|\text{Pt}(s)$

3.5 $E_{\text{cell}} = E_{\text{cathode}} - E_{\text{anode}}$

$E_{\text{cell}} = 0 - E_{\text{anode}}$

$2,36 = 0 - E_{\text{anode}}$

$\therefore E_{\text{anode}} = -2,36\ \text{V}$

3.6 $\text{Mg}(s) + 2\text{H}^+(aq) \rightarrow \text{Mg}^{2+}(aq) + \text{H}_2(g)$

4.

4.1 Salt bridge. The function of the salt bridge is to complete a circuit (it allows movement of ions between the half-cells/to maintain neutrality)

4.2 Pb^{2+} ion

4.3 $E_{\text{cell}} = E_{\text{cathode}} - E_{\text{anode}}$

$1,53 = -0,13 - E_{\text{anode}}$

$E_{\text{anode}} = -0,13 - 1,53$

$\therefore E_{\text{anode}} = -1,66\ \text{V}$

Therefore the metal X is the aluminium electrode.

4.4 $\text{Al}(s) + \text{Pb}^{2+}(aq) \rightarrow \text{Al}^{3+}(aq) + \text{Pb}(s)$

5.

5.1

5.1.1. Au^{3+} ions

5.1.2. $2\ \text{Cl}^- \rightarrow \text{Cl}_2 + 2e^-$

5.1.3. $\text{Pt}(s)|\text{Cl}^-(aq)|\text{Cl}_2(g)||\text{Au}^{3+}(aq)|\text{Au}(s)$

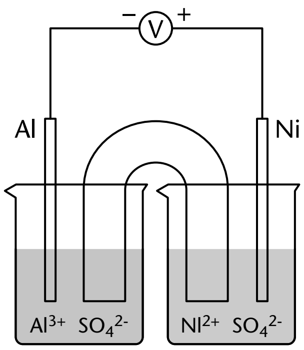
5.2 $E_{\text{cell}} = C_{\text{cathode}} - E_{\text{anode}}$

$0,14 = E_{\text{cathode}} - 1,36$

$E_{\text{cathode}} = 1,5\ \text{V}$

6.

6.1



6.2 $Al \rightarrow Al^{3+} + 3e^-$

6.3 $Ni^{2+} + 2e^- \rightarrow Ni$

6.4 $2\ Al + 3\ Ni^{2+} \rightarrow 2\ Al^{3+} + 3\ Ni$

6.5 $E_{cell} = E_{cathode} - E_{anode}$

$E_{cell} = -0,27 - (-1,66) = 1,39\ V$

6.6 $Al(s)|Al^{3+}(aq)||Ni^{2+}(aq)|Ni(s)$

7.

- Complete a circuit for electrons to flow in a voltaic cell
- Maintain electrical neutrality of the solutions making up the cells by allowing the free movement of the ions between the two cells.

8.

Galvanic Cell	Electrolytic Cell
A Galvanic cell converts chemical energy into electrical energy.	An electrolytic cell converts electrical energy into chemical energy.
Here, the redox reaction is spontaneous and is responsible for the production of electrical energy.	The redox reaction is not spontaneous and electrical energy has to be supplied to initiate the reaction.
The two half-cells are set up in different containers, being connected through the salt bridge or porous partition.	Both the electrodes are placed in a same container in the solution of molten electrolyte.
Here the anode is negative and cathode is the positive electrode. The half-reaction at the anode is oxidation and that at the cathode is reduction.	Here the anode is positive and cathode is the negative electrode. The half-reaction at the anode is oxidation and that at the cathode is reduction.
The electrons are supplied by the species getting oxidized. They move from anode to the cathode in the external circuit.	The external battery supplies the electrons. They enter through the cathode and come out through the anode.

Biodiesel fuel:

- Food shortage: Since biofuels are made from animal and vegetable fat, more demand for these products may raise prices for these products and create food crisis in some countries. For e.g.: the production of biodiesel from corn may raise its demand and it might become more expensive which may deprive poor people from having it.

- Increased use of fertilisers: As more crops are grown to produce biofuels, more fertilizer is used which can have devastating effect on environment. The excess use of fertilizers can result in soil erosion and can lead to land pollution.
- Clogging in engine: Biodiesel cleans dirt from the engine. This proves to be an advantage of biofuels but the problem is that this dirt gets collected in fuel filter and clogs it.
- Water shortage: The use of water to produce more crops can put pressure on local water resources. The areas where there is water scarcity, production of crops to be used in making of biofuels is not a wise idea.

Hydrogen Fuel cell:

- Fossil fuels are still needed: In order to separate the atoms of the hydrogen and oxygen and actually generate hydrogen fuel, fossil fuels are needed. This completely defeats the purpose of an alternative energy source. If we ran out of fossil fuels we would no longer be able to produce hydrogen energy.
- Costly to produce: One of the biggest pitfalls of hydrogen fuel cells is the simple fact that it is very expensive to produce. As of now, the energy is not efficient enough to produce hydrogen energy in a cost-effective way.
- Flammable: While it may not be toxic, it sure is flammable. The source of the hazard comes from the hydrogen itself, which is very prone to catching on fire, or even exploding. This would add unnecessarily and new risks into society.

Photovoltaic cell

- Some toxic chemicals, like cadmium and arsenic, are used in the PV production process. These environmental impacts are minor and can be easily controlled through recycling and proper disposal.
- Solar energy is somewhat more expensive to produce than conventional sources of energy due in part to the cost of manufacturing PV devices and in part to the conversion efficiencies of the equipment. As the conversion efficiencies continue to increase and the manufacturing costs continue to come down, PV will become increasingly cost competitive with conventional fuels.
- Solar power is a variable energy source, with energy production dependent on the sun. Solar facilities may produce no power at all some of the time, which could lead to an energy shortage if too much of a region's power comes from solar power.

Rubrics

A rubric is an assessment tool which defines different levels of performance. It can be used for assessing concepts and process skills during informal and formal assessment, and for practical work. Rubrics aim to make assessment more objective and consistent. Some of the advantages of using rubrics are:

- Learners become aware of the expectations of teachers
- Teachers become aware of learners' progress and potential
- Enhance greater learner involvement
- Learners are more focused and self-directed.

Examples of rubrics: Assessment of practical work

Planning and organising experimental investigations to test hypotheses

Criteria	7–6	5–3	2–0
Plan should reflect process of identification of variables, control of variables, range of conditions, ways in which the experiment could be improved, awareness of inaccuracies, offering of a conclusion.	Able to plan independently an experiment in which all variables are identified and controlled as necessary. Able to suggest ways in which the experiment could be improved.	Able to plan independently an experiment to test a hypothesis in which most of the variables are identified and controlled as necessary.	Able to plan a one-step experiment to test the hypothesis.

Following instructions and manipulations

Criteria	7–6	5–3	2–0
Accurately following a sequence of written/ verbal instructions.	Following a sequence of instructions including branched instructions.	Can complete an experiment by following a sequence of instructions.	Able to follow a single written, diagrammatic or verbal instruction.
Selecting/using the appropriate apparatus.	Select in advance all the apparatus needed to execute a particular experiment and be able to use it.	Able to select/use most of the apparatus necessary; some more specialized equipment may still be needed.	Able to select/use only the most basic apparatus.
Manipulative skills include correct and safe handling of apparatus and material.	Able to use all apparatus and material correctly and safely.	Use most of the apparatus and material safely.	Able to use only the most basic equipment.

Making accurate observations and measurements, being aware of possible sources of error

Criteria	7–6	5–3	2–0
Accuracy, completeness and relevance of observations.	Able to make a complete sequence of observations in a given situation and is aware of a number of sources of error.	Able to make a range of observations in a given situation and is able to suggest one possible source of error.	Able to make a single observation and more if prompted, e.g.: What did you observe regarding colour and smell or temperature in test tube?
Selection of measurement instrument, performance of measuring operation and reading scales.	Able to read a variety of scales as accurately as the scale permits.	Able to read a scale to the nearest division.	Able to read scales within ± one numbered scale division.

Criteria for check lists could be more differentiated when directed towards specific experiments in Chemistry or Physics.

Regarding the scope of observations properties, similarities and differences taking place in colour, hardness, mass, relative speed, size, smell, sound, state, temperature, texture, volume, voltages could be listed.

The performance of measuring which might be used for assessment could be listed as:

1. Is the instrument capable of measuring the correct amount?
2. Was the correct range of the instrument selected?
3. Were the necessary precautions taken to ensure that the measurements will be valid?
4. Are measurements repeated or checked?
5. Are readings made with due regard for parallax?

Recording accurately and clearly the results of experiments

Criteria for Processing Data	7–6	5–3	2–0
All the observations are described accurately and completely. **Appropriate methods (written, tables, diagrams) used to record observations and measurements.**	Able to draw fully labelled diagrams to record observations. Able to record results in neat tables with appropriate headings and units, with all measurements recorded as well as derived quantities.	Data recorded as an ordered set of statements, or in a table some data and units omitted.	Information recorded as a prose account, as a sequence of statements. Able to record data in a pre-prepared table.

Presentation of data in graphic form

Criteria	7–6	5–3	2–0
Acceptable scale. **X-axis correctly labelled.** **Units on x-axis.** **Y-axis correctly labelled.** **Units on y-axis.** **Points correctly marked.** **Points correctly linked.** **Contradictory results 'normalised'.** **Appropriate subtitle.**	All the criteria could be met without assistance.	All criteria could be met with help.	Graphs could only be drawn with pre-prepared axes, with a lot of assistance.

Drawing conclusions and making generalisations from experiments

Criteria	7–6	5–3	2–0
Valid deductions from results.	Able to identify patterns or relationships and explain fundamental principles, verbal or in mathematical terms.	Able to identify a pattern, simple or trend in the relationship between two variables. Perform simple calculations of a derived quantity.	Classifications of observations and recognition of similarities and differences. Able to explain a simple observation.