Mindset Learn Xtra Exam School

The Department of Basic Education proudly endorses the Mindset Learn Spring School programme

Mindset Learn Xtra Exam School is brought to you by
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INTRODUCTION

Have you heard about Mindset? Mindset Network, a South African non-profit organisation, was founded in 2002. We develop and distribute quality and contextually relevant educational resources for use in the schooling, health and vocational sectors. We distribute our materials through various technology platforms like TV broadcasts, the Internet (www.mindset.co.za/learn) and on DVDs. The materials are made available in video, print and in computer-based multimedia formats.

At Mindset we are committed to innovation. In the last three years, we have successfully run a series of broadcast events leading up to and in support of the Grade 12 NSC examinations.

Now we are proud to announce our 2012 edition of Exam School. From 15th October till 20th November will bring you revision lessons in nine subjects - Mathematics, Physical Sciences, Life Sciences, Mathematical Literacy, English 1st Additional Language, Accounting, Geography, Economics and Business Studies.

In this exam revision programme we have selected Questions mainly from the Nov 2011 Papers and have tried to cover as many topics as we can. Each topic is about an hour long and if you work through the selected questions you will certainly have increased confidence to face your exams. In addition to the topics and questions in this booklet, we have schedule 1½ hour live shows a day or two before you write your exams. To get the most out of these shows, we need you to participate by emailing us questions, calling in or posting on twitter, peptxt or facebook.

Since you asked us for late night study sessions and that’s what we’ve planned! You’ll find repeats of our Live shows at 10:30pm every evening. Then from midnight to 6:00 am there are revision lessons too. So if you can’t watch during the day, you can record or watch early in the morning!

GETTING THE MOST FROM EXAM SCHOOL

You must read this booklet! You’ll find the exam overviews and lots of study tips and hints here. In Start your final revision by working through the questions for a topic fully without looking up the solutions. If you get stuck and can’t complete the answer don’t panic. Make a note of any questions you have. Now you are ready to watch a Learn Xtra session. When watching the session, compare the approach you took to what the teacher does. Don’t just copy the answers down but take note of the method used. Also make a habit of marking your work by checking the memo. Remember, there are usually more than one way to answer a question. If you still don’t understand post your question on Facebook – you’ll get help from all the other Mindsetters on the page. You can also send an email to helpdesk@learnxtra.co.za and we’ll get back to you within 48 hours.

Make sure you keep this booklet. You can re-do the questions you did not get totally correct and mark your own work. Exam preparation requires motivation and discipline, so try to stay positive, even when the work appears to be difficult. Every little bit of studying, revision and exam practice will pay off. You may benefit from working with a friend or a small study group, as long as everyone is as committed as you are.
We are pleased to announce that we’ll continue to run our special radio broadcasts on community radio stations in Limpopo, Eastern Cape and KZN. This programme is called MTN Learn. Find out more details at www.mtnlearning.co.za. You can also listen online or download radio broadcasts of previous shows. Tuning into radio will give you the chance to learn extra! Look out for additional notes in Newspaper supplements too.

Mindset believes that the 2012 Learn Xtra Spring School will help you achieve the results you want. All the best to the Class of 2012!

CONTACT US
We want to hear from you. So let us have your specific questions or just tell us what you think through any of the following:

LearnXtra helpdesk@learnxtra.co.za

@learnxtra 086 105 8262

www.learnxtra.co.za Mindset

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## Broadcast Schedules

**Exam School (DSTV and TopTV 319)**

### Physical Sciences Paper 1

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EXAM SCHOOL RADIO BROADCAST: MTN LEARN

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Visit www.mtnlearning.co.za for the complete schedule, and free downloads of booklets and past shows.

MTN Learn: Participating Community Radio Stations

KwaZulu Natal:
Hindvani Radio 91.5 fm – Durban
Maputaland Radio 102.3 fm – Rest or KZN

Limpopo Province:
Sekgosese Radio 100.3 fm
Greater Tzaneen Radio 104.8 fm
Mohodi FM 98.8 fm
Moletsi 98.6 fm
Univen 99.8 fm

Eastern Cape:
Vukani fm 90.6 – 99.9 fm
Fort Hare Community Radio 88.2 fm
Mdantsane fm 89.5 fm
Nkqubela fm 97.0 fm
Graaff Reinet 90.2 fm
PREPARING FOR EXAMINATIONS

1. Prepare well in advance for all your papers and subjects. You need to start your planning for success in the final examination now. You cannot guarantee success if you only study the night before an exam.

2. Write down the date of your prelim and final exam so that you can plan and structure a study time table for all your subjects.

3. Set up a study time-table according to your prelim and final Grade 12 exam time-table and stick to your study schedule. If you study a small section every day, you will feel you have achieved something and you will not be as nervous by the time you have to go and write your first paper.

4. Your study programme should be realistic. You need to spend no more than 2 hours per day on one topic. Do not try to fit too much into one session. When you cover small sections of work often, you will master them more quickly. The broadcast schedule may help you to make sure you have covered all the topics that are in the exam.

5. When studying don’t just read through your notes or textbook. You need to be active by making summary checklists or mind maps. Highlight the important facts that you need to memorise. You may need to write out definitions and formulae a few times to make sure you can remember these. Check yourself as often as you can. You may find it useful to say the definitions out aloud.

6. Practise questions from previous examination papers. Follow these steps for using previous exam papers effectively:
   - Take careful note of all instructions - these do not usually change.
   - Try to answer the questions without looking at your notes or the solutions.
   - Time yourself. You need to make sure that you complete a question in time. To work out the time you have, multiply the marks for a question by total time and then divide by the total number of marks. In most exams you need to work at a rate of about 1 mark per minute.
   - Check your working against the memo. If you don’t understand the answer given, contact the Learn Xtra Help desk (email: helpdesk@learnxtra.co.za).
   - If you did not get the question right, try it again after a few days.

7. Preparing for, and writing examinations is stressful. You need to try and stay healthy by making sure you maintain a healthy lifestyle. Here are some guidelines to follow:
   - Eat regular small meals including breakfast. Include fruit, fresh vegetables, salad and protein in your diet.
   - Drink lots of water while studying to prevent dehydration.
   - Plan to exercise regularly. Do not sit for more than two hours without stretching or talking a short walk.
   - Make sure you develop good sleeping habits. Do not try to work through the night before an exam. Plan to get at least 6 hours sleep every night.
EXAM TECHNIQUES

1. Make sure you have the correct equipment required for each subject. You need to have at least one spare pen and pencil. It is also a good idea to put new batteries in your calculator before you start your prelims or have a spare battery in your stationery bag.

2. Make sure you get to the exam venue early - don’t be late.

3. While waiting to go into the exam venue, don’t try to cram or do last minute revision. Try not to discuss the exam with your friends. This may just make you more nervous or confused.

4. Here are some tips as to what to do when you receive your question papers:
   Don’t panic, because you have prepared well.
   - You are always given reading time before you start writing. Use this time to take note of the instructions and to plan how you will answer the questions. You can answer questions in any order.
   - Time management is crucial. You have to make sure that you answer all questions. Make notes on your question paper to plan the order for answering questions and the time you have allocated to each one.
   - It is a good idea always to underline the key words of a question to make sure you answer it correctly.
   - Make sure you look any diagrams and graph carefully when reading the question. Make sure you check the special answer sheet too.
   - When you start answering your paper, it is important to read every question twice to make sure you understand what to do. Many marks are lost because learners misunderstand questions and then answer incorrectly.
   - Look at the mark allocation to guide you in answering the question.
   - When you start writing make sure you number your answers exactly as they are in the questions.
   - Make sure you use the special answer sheet to answer selected questions.
   - Think carefully before you start writing. It is better to write an answer once and do it correctly than to waste time rewriting answers.
   - DO NOT use correction fluid (Tippex) because you may forget to write in the correct answer while you are waiting for the fluid to dry. Rather scratch out a wrong answer lightly with pencil or pen and rewrite the correct answer.
   - Check your work. There is usually enough time to finish exam papers and it helps to look over your answers. You might just pick up a calculation, language or a spelling error. In Physical Sciences make sure that every answer has the correct units. For vector quantities (force, displacement, velocity, acceleration, momentum, impulse and electric field strength) make sure you include the direction as well.
EXAM OVERVIEW

STRUCTURE OF PHYSICAL SCIENCES EXAM PAPERS

Section A (All topics)
One word answers 5 marks
Multiple choice questions 20 marks

Section B (Long questions) 125 marks

PHYSICAL SCIENCE PAPER 1: PHYSICS TOTAL MARKS: 150 3 HOURS

Mechanics ±50 marks
● Momentum in 1 D Grade 11
● Impulse and change in momentum
● Vertical projectile motion
● Frames of reference
● Work, power and energy

Waves, Sound and Light ±25 marks
● Doppler effect
● 2D and 3D wave fronts

Electricity and Magnetism ±55 marks
● Electrostatics Grade 11
● Electric circuits Grade 11
● Electrodynamics Grade 12
● Electromagnetic radiation Grade 12

Matter and Materials ±20 mark
● Optical phenomena and properties of materials

PHYSICAL SCIENCE PAPER 2: CHEMISTRY TOTAL MARKS: 150 3 HOURS

Matter and Materials ±50 marks
● Organic molecules

Chemical Change ±75 marks
● Energy and chemical change Grade 11
● Rate and extent of reactions
● Electrochemical reactions

Chemical Systems ±25 marks
● Chlor-alkali industry
● Fertiliser industry
● Batteries
### MECHANICS

#### FORCE, MOMENTUM AND IMPULSE (GRADE 11)

**Pairs of interacting objects exert equal forces on each other (Newton’s Third Law)**
- State Newton’s Third Law (N3): When pairs of objects interact they exert forces on each other. These forces are equal in size and point in opposite directions.
- Differentiate between contact and non-contact forces.
- Apply Newton’s Third Law (N3) to contact and non-contact forces.
- Identify N3 pairs e.g. donkey pulling a cart, a book on a table.

**Momentum**
- Define momentum.
- Calculate the momentum from a moving object using \( p = mv \).
- Describe the vector nature of momentum and illustrate with some simple examples.

**A net force on an object causes a change in momentum – if there is no net force on an object/system its momentum will not change (momentum will be conserved)**
- State Newton’s Second Law (N2) in terms of momentum: the net (or resultant) force acting on an object is equal to the rate of change of momentum.
- Express Newton 2 in symbols: \( F_{\text{net}} = \frac{\Delta p}{\Delta t} \).
- Explain the relationship between net force and change in momentum for a variety of motions.
- Calculate the change in momentum when a resultant force acts on an object and its velocity.
  - Increases in the direction of motion (e.g. 2nd stage rocket engine fires)
  - Decreases (e.g. brakes are applied).
  - Reverses its direction of motion e.g. a soccer ball kicked back in the direction it came from.
- Draw vector diagrams to illustrate the relationship between the initial momentum, the final momentum and the change in momentum in each of the above cases.
- Know that in the absence of an external force acting on a system momentum is conserved.
- Apply the conservation of momentum to collisions of two objects moving in one dimension (along a straight line).

**Momentum (Grade 12)**
- Know that the momentum of a system is conserved when no external forces act on it.
- Know that an external force causes the momentum to change. Define impulse as \( F_{\text{net}} \Delta t = \Delta p \) and use the equation in calculations.
- Distinguish between elastic and inelastic collisions.
- Solve problems involving impulse and change in momentum when the applied force is in the horizontal or vertical direction.
- Solve problems involving elastic and inelastic collisions for objects moving along the same straight line.
- Apply the concept of impulse to safety considerations in everyday life, e.g. airbags, seatbelts and arrestor beds.
VERTICAL PROJECTILE MOTION

For vertical projectile motion (near the surface of the Earth if air friction is ignored)
- Explain that projectiles
  - Fall freely with gravitational acceleration 'g'
  - Accelerate downwards with a constant acceleration whether the projectile is moving upward or downward
  - Have zero velocity at their greatest height
  - Take the same time to reach their greatest height from the point of upward launch as the time they take to fall back to the point of launch
  - Can have their motion described by a single set of equations for the upward and downward motion

Use equations of motion, for e.g. to determine
- The greatest height reached given the velocity with which the projectile is launched upward (initial velocity)
- The time at which a projectile is at a particular height given its initial velocity
- The height relative to the ground of the position of a projectile shot vertically upward at launch, given the time for the projectile to reach the ground

Draw position vs time (x vs t), velocity vs time (v vs t) and acceleration vs time (a vs t) graphs for projectile motion.

Give equations for position versus time and velocity versus time for the graphs of motion of particular projectiles and vice versa.

Given x vs t, v vs t or a vs t graphs determine position, displacement, velocity or acceleration at any time t.

Describe the motion of the object e.g. graphs showing a ball:
- Bouncing
- Thrown vertically upwards
- Thrown vertically downward, and so on

Frames of reference (Relative velocity)

For motion in one dimension (linear motion) only:
- Define a frame of reference.
- Give examples of the importance of specifying the frame of reference.
- Define relative velocity.
- Specify the velocity of an object relative to different frames of reference, e.g. for a person walking inside a train give the velocity relative to the train and relative to the ground.
- Use vectors to find the velocity of an object that moves relative to something else that is itself moving.
### WORK, POWER AND ENERGY

#### When a force exerted on an object causes it to move, work is done on the object
- Define the work done on an object by a force.
- Give examples of when an applied force does and does not do work on an object.
- Calculate the work done by an object when a force \( F \) applied at angle \( \theta \) to the direction of motion causes the object to move a distance, using \( W = F \Delta x \cos \theta \).

#### The work done by an external force on an object / system equals the change in kinetic energy of the object / system
- Know that an object with larger potential energy has a greater capacity to do work.
- Solve problems using the work energy theorem, i.e. the work done on an object is equal to the change in its kinetic energy: \( W = \Delta E_k = E_{kf} - E_{ki} \).
- Examples may include:
  - objects on horizontal surfaces
  - objects moving in a vertical plane
  - objects on inclined planes
- Conservation of mechanical energy. (prior knowledge from grade 10)

#### Power (rate at which work is done)
- Define power as the rate at which work is done or energy is expended.
- Calculate the power involved when work is done.
  - If a force causes an object to move at a constant velocity, calculate the power using \( P = Fv \).
- Apply to real life examples, e.g. the minimum power required of an electric motor to pump water from a borehole of a particular depth at a particular rate, the power of different kinds of cars operating under different conditions.

### WAVES, SOUND AND LIGHT

#### DOPPLER EFFECT
- State what the Doppler Effect is for sound and give everyday examples.
- Relate the pitch of a sound wave to the frequency of a sound wave and explain why a sound increases in pitch when the source of the sound travels towards a listener and decreases in pitch when it travels away.
- Use the equation \( f_L = \frac{v \pm v_L}{v \pm v_S} f_S \) to calculate the frequency of sound detected by a listener (L) when either the listener or the source (S) is moving.
- Describe applications of the Doppler Effect with ultrasound waves in medicine, e.g. to measure the rate of blood flow or the heart of a fetus in the womb.

#### 2D AND 3D WAVEFRONTS
- Define a wavefront as an imaginary line that connects waves that are in phase (e.g. all at the crest of their cycle)
- State Huygen’s principle.
- Define diffraction as the ability of a wave to spread out in wavefronts as they pass through a small aperture or around a sharp edge.
- Apply Huygen’s principle to explain diffraction qualitatively. Light and dark areas can be described in terms of constructive and destructive interference of secondary wavelets.
- Sketch the diffraction pattern for a single slit.
- Use \( \sin \theta = \frac{m \lambda}{a} \) for a slit of width \( a \) to calculate the position (angle from the horizontal) of the dark bands in a single slit diffraction pattern, where \( m = \pm 1, \pm 2, \pm 3, \ldots \).
### Interference (special kind of superposition)

- Define interference as when two waves pass through the same region of space at the same time, resulting in superposition of waves.
- Explain the concepts of constructive and destructive interference.
- Predict areas of constructive and destructive interference from a diagram/source material.
- Investigate the interference of waves from two coherent sources vibrating in phase e.g. light waves through a double slit.
- Draw an interference pattern marking nodal lines and noting positions of maximum interference e.g. interference pattern for a double slit.

### ELECTRICITY AND MAGNETISM

#### ELECTROSTATICS (GRADE 11)

**Forces charges exert on each other (Coulomb’s Law)**

- State Coulomb’s Law, which can be represented mathematically as $F = \frac{kQ_1Q_2}{r^2}$.
- Solve problems using Coulomb’s Law to calculate the force exerted on a charge by one or more charges in one dimension.

**Electric field around single charges and groups of charges**

- Describe an electric field as a region of space in which an electric charge experiences a force. The direction of the electric field at a point is the direction that a positive test charge would move if placed at that point.
- Draw electric field lines for various configurations of charges.
- Define the magnitude of the electric field at a point as the force per unit charge ($E = \frac{F}{q}$). $E$ and $F$ are vectors.
- Deduce that the force acting on a charge in an electric field is $F = Eq$.
- Calculate the electric field at a point due to a number of point charges, using the equation $E = \frac{kQ}{r^2}$ to determine the contribution to the field due to each charge.

**Electrical potential energy and potential**

- Define the electrical potential energy of a charge as the energy it has because of its position relative to other charges that it interacts with.
- Use the equation $U = \frac{kQ_1Q_2}{r}$ to calculate the potential energy of a charge due to other charges.
- Define the electric potential at a point as the electrical potential energy per unit charge, i.e. the potential energy a positive test charge would have if it were placed at that point.
- Define electric potential difference as the difference in electrical potential energy per unit charge between two points ($V = \frac{W}{q}$). The unit is volt (V), which is the same as joule per coulomb. Thus electrical potential difference is also called voltage. (revision from Grade 10)
- Explain lightning in terms of electric potential and potential difference and describe measures that can be taken to reduce the risk of being struck by lightning.
Capacitance, physics of the parallel plate capacitor, relation between charge, potential difference and capacitance

- Describe a parallel plate capacitor as a device that consists of two oppositely charged conducting plates separated by a small distance, which stores charge.
- Define capacitance as the charge stored per volt, measured in farad (F), mathematically, $C = \frac{Q}{V}$.
- Solve problems involving the charge stored by, and voltage across, capacitors.
- Use the equation $C = \frac{\varepsilon_0 A}{d}$ to determine the capacitance of a capacitor of given dimensions or design a capacitor of given capacitance.
- Calculate the electric field between the plates of a parallel plate capacitor using the equation $E = \frac{V}{d}$.
- Explain using words and pictures why inserting a dielectric between the plates of a parallel plate capacitor increases its capacitance.

Capacitor as a circuit device

- Describe what happens to a capacitor in a DC circuit over time.
- Describe how a charged capacitor can be used to provide a large potential difference for a very short time.

ELECTRIC CIRCUITS (GRADE 11)

Relation between current, voltage and resistance (Ohm’s Law)

- Define electric current. Calculate electric current strength using $I = \frac{q}{\Delta t}$.
- Determine the relationship between current, voltage and resistance at constant temperature using a simple circuit.
- State the difference between ohmic and non-ohmic conductors, and give an example of each.
- Solve problems using the mathematical expression of Ohm’s Law, $R=V/I$.
- Calculate the work done or energy transferred in an electric circuit using $W = Vq = Vt \Delta t = I^2Rt = \frac{V^2\Delta t}{R}$.
- Calculate the electric power dissipated in an electric circuit using $P = \frac{W}{\Delta t} = Vt = I^2R = \frac{V^2}{R}$. Use power to determine, for example, relative brightness of bulbs.

Resistance, equivalent resistance, internal resistance

- Calculate the equivalent resistance of series and parallel arrangements of resistors.
- Solve problems involving current, voltage and resistance for circuits containing arrangements of resistors in series and in parallel.
- State that a real battery has internal resistance.
- Explain why there is a difference between the emf and terminal voltage of a battery if the load (external resistance in the circuit) is comparable in size to the battery’s internal resistance.
- Solve circuit problems in which the internal resistance of the battery must be considered.

Series, parallel networks

Solve circuit problems involving resistors in series with a maximum of three resistors in parallel.
### ELECTRODYNAMICS

#### Electrical machines (generators, motors)
- State that generators convert mechanical energy to electrical energy and motors convert electrical energy to mechanical energy.
- Use Faraday’s Law to explain why a current is induced in a coil that is rotated in a magnetic field.
- Use words and pictures to explain the basic principle of an AC generator (alternator) in which a coil is mechanically rotated in a magnetic field.
- Use words and pictures to explain how a DC generator works and how it differs from an AC generator.
- Explain why a current-carrying coil placed in a magnetic field (but not parallel to the field) will turn by referring to the force exerted on moving charges by a magnetic field and the torque on the coil.
- Use words and pictures to explain the basic principle of an electric motor.
- Give examples of the use of AC and DC generators.
- Give examples of the use of motors.

#### Alternating current
- Explain the advantages of alternating current.
- Write expressions for the current and voltage in an AC circuit.
  $$I_{\text{rms}} = \frac{I_{\text{max}}}{\sqrt{2}} \quad \text{and} \quad V_{\text{rms}} = \frac{V_{\text{max}}}{\sqrt{2}}$$
- Calculate the average power in an AC circuit using:
  $$P_{\text{average}} = V_{\text{rms}}I_{\text{rms}} = I_{\text{rms}}^2R = \frac{V_{\text{rms}}^2}{R}$$
- Draw a graph of voltage vs time and current vs time for an AC circuit.

### ELECTROMAGNETIC RADIATION

#### Dual (particle/wave) nature of EM radiation
- Explain that some aspects of the behaviour of EM radiation can best be explained using a wave model and some aspects can best be explained using a particle model.

#### Nature of an EM-wave as mutual induction of oscillating magnetic/electric fields
- Describe the source of electromagnetic waves as an accelerating charge.
- Use words and diagrams to explain how an EM wave propagates when an electric field oscillating in one plane produces a magnetic field oscillating in a plane at right angles to it, which produces an oscillating electric field, and so on.
- State that these mutually regenerating fields travel through space at a constant speed of $3 \times 10^8 \text{ m/s}$, represented by $c$.

#### EM spectrum
- Given a list of different types of EM radiation, arrange them in order of frequency or wavelength.
- Given the wavelength of EM waves, calculate the frequency and vice versa, using the equation $c = f\lambda$.
- Give an example of the use of each type of EM radiation, i.e. gamma rays, X-rays, ultraviolet light, visible light, infrared, microwave and radio and TV waves.

#### Nature of EM as particle – energy of a photon related to frequency and wavelength
- Calculate the energy of a photon using $E = hf = \frac{hc}{\lambda}$. 
Penetrating ability

- Indicate the penetrating ability of the different kinds of EM radiation and relate it to energy of the radiation.
- Describe the dangers of gamma rays, X-rays and the damaging effect of ultra-violet radiation on skin.

MATTER AND MATERIALS (INTEGRATED TOPICS WITH A PHYSICS FOCUS)

OPTICAL PHENOMENA AND PROPERTIES OF MATERIALS

Transmission and scattering of light

- Explain the interaction of UV and visible radiation:
  - With metals: reflect (absorb and re-emit)
  - In terms of the interaction with electromagnetic radiation

- Explain why the sky is blue.

Photoelectric effect

- Describe the photoelectric effect as the process that occurs when light shines on a metal and it ejects an electron.

- Explain the photoelectric effect in terms of photons and work function.

- Recall, use and explain the significance of \( hf = W_0 + \frac{1}{2}mv^2 \) where \( W_0 \) is the work function of a surface.

- Give the significance of the photo-electric effect:
  - It establishes the quantum theory.
  - It illustrates the particle nature of light.

Emission and absorption spectra

- Explain the source of atomic emission spectra (cf discharge tubes) and their unique relationship to each element.

- Relate the lines on the atomic spectrum to electron transitions between energy levels.

- Explain the difference between of atomic absorption and emission spectra.

- Use \( E = hf \) to determine the energy of photons of UV and visible light of varying colours.

- Relate UV and visible light to atomic absorption spectra.

- State that lasers emit light which is monochromatic and in phase.

- Explain – in simple terms – how a laser works. Include concepts of a meta-stable state, population inversion and the consequence of decay of some atoms from the meta-stable state and their subsequent stimulation of other excited atoms to emit photons in phase with this emission.

- Recognize that the materials used for lasers all allow a population inversion to be set up and that materials which have been used include synthetic ruby, a mixture of helium and neon (He-Ne lasers) and various semiconductors.

- Describe the arrangement of the laser cavity and its effects of:
  - Increasing amplification
  - Concentrating beam intensity
  - Improving the spectral purity of the beam (narrowing the frequency of the beam.)

- Identify some advantages of laser applications in respect of: barcodes; laser communication and fibre-optics; medical lasers; laser printers; optical storage media.
VERTICAL PROJECTILE MOTION & MOMENTUM

Check List
Make sure you can:
- Draw and interpret graphs of motion (position vs time, velocity vs time and acceleration vs time)
- Use equations of motion to solve problems
- State the Law of Conservation of Momentum
- Solve problems when momentum is conserved
- Identify elastic and inelastic collisions
- Define and calculate impulse

STUDY NOTES

VERTICAL PROJECTILE MOTION

1. What is Projectile Motion?
A projectile is an object that is given an initial velocity by shooting or throwing etc., and once launched, the only force acting on it is the force due to gravity. In the absence of air resistance, the object is free falling with a constant (uniform) acceleration of 9.8 m·s⁻² called gravitational acceleration (g). The direction of this acceleration is always downwards.

2. Important Facts Concerning Vertical Projectile Motion:
- At the greatest height of the upward motion:
  \[ v_f = 0 \text{ m·s}^{-1} \]
  \[ a = g = 10 \text{ m·s}^{-2} \text{ downwards} \]
- The object will take the same time to reach its greatest height from point of upwards launch as the time taken to fall back to point of launch
- If the object is being released from rest or being dropped, its initial velocity is 0 m·s⁻¹.
- If the object is being thrown upwards, it must start with a maximum velocity and as it moves up, the velocity decreases until it stops.
- When an object is thrown upwards, you can treat the motion as two parts (upwards and downwards) or as a single motion, but the acceleration must be constant throughout the time. The sign of the direction of motion must stay the same as well.

3. The Effect of Air Resistance
- In most exam questions you will be told to ignore the effects of air resistance.
- Air resistance is a frictional force that opposes motion.
- When an object is moving up, air resistance will act downwards.
- When an object is moving downwards, air resistance will act upwards.
- Terminal velocity is reached when the downward force of gravity and the upward force of air resistance are equal.
- At terminal velocity there is no net force acting in on the object and so the acceleration is zero and the object falls at a constant velocity.
4. **Solving Vertical Projectile Motion Problems**

To solve vertical projectile motion problem we use equations of motion and graphs of motion.

**Equations of Motion:**

These are found on the information sheet and are used to describe and calculate the motion of an object that is moving in one direction with a constant acceleration.

**Method for Using Equations of Motion:**

**STEP 1:** Draw a diagram of the situation in the question and enter all the numerical values onto your diagram.

**STEP 2:** Select a direction as positive and do not change the sign of the direction.

**STEP 3:** Identify which equation to use, i.e. identify the known and unknown quantities.

**STEP 4:** Substitute into the equation and solve.

**STEP 5:** Interpret the answer - for vector quantities, give the direction in words.

**Graphs of Motion**

We use three different graphs.

A. position – time graph
B. velocity – time graph
C. acceleration – time graph

**Interpreting Graphs of Motion**

- Check the labels and units on the horizontal and vertical axes.
- When the graph is above the horizontal axis, the position, velocity or acceleration is positive. Identify the direction of motion from the graph.
- The gradient of a position-time graph tells you about the velocity of the object and the gradient of a velocity-time graph tells you about the acceleration of the object.
- The area between the graph and the time axis on a velocity-time graph gives the change in position, and on an acceleration-time graph this area is the velocity.
- Use a ruler to read off values - start on the time axis and graph a vertical line till it touches the graph; then graph a horizontal line and read off the value on the vertical axis.
- Make sure you know what all three graphs of motion look like for the following situations:
  - an object dropped from a height above the ground
  - an object that is thrown up from the ground and falls back down again
  - a ball that is dropped from a height and bounces up off the ground
Sketching Graphs of Motion

- Select the position of the observer (usually represented as the origin)
- Make sure you label the axes with units
- Select a good scale for an accurate graph
- Learn the basic shape of each of the graphs for the following situations:
  - stationary object
  - constant velocity moving towards and away
  - constant acceleration moving towards and away
- Make sure you know when the velocity is zero
- Make sure you know when the velocity is increasing or decreasing
- Plot your points accurately
- After drawing the sketch check that the sketch describes the situation given

MOMENTUM

Definition: Momentum is a vector quantity and has the unit: kg·m·s⁻¹.

\[ p = mv \]

The Principle of Conservation of Linear Momentum

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

Impulse

Definition: Impulse is the change in momentum of a body \( \Delta p = m \Delta v = m(v_f - v_i) \)

Impulse and Newton’s 2nd Law

Newton’s 2nd Law states that the net force exerted on an object is directly proportional to the rate of change of momentum in the direction of the force net.

Equation:

\[ F_{\text{net}} = m \frac{\Delta v}{\Delta t} \]

Equation for Impulse:

\[ F_{\text{net}} \cdot \Delta t = m \Delta v \]

Units for Impulse:

\( N \cdot s \)

Collisions

We classify collisions as either elastic or inelastic.

- In an elastic collision kinetic energy and momentum are conserved.
- In an inelastic collision, momentum is conserved, but not kinetic energy.

The conservation of kinetic energy is determined by calculating the total kinetic energy of all parts of the closed system before the collision and comparing that to the total kinetic energy of all the parts of the closed system after the collision.
Question 1 (Adapted from Nov 2011, P1, Question 3)

A hot-air balloon is moving vertically upwards at a constant speed. A camera is accidentally dropped from the balloon at a height of 92.4 m as shown in the diagram below. The camera strikes the ground after 6 s. Ignore the effects of friction.

1.1 At the instant the camera is dropped, it moves upwards. Give a reason for this observation.  

(1)

1.2 Calculate the speed \( v_i \) at which the balloon is rising when the camera is dropped.  

(4)

1.3 Draw a sketch graph of velocity versus time for the entire motion of the camera.  

Indicate the following on the graph:  

- Initial velocity  
- Time at which it reaches the ground  

(4)

1.4 If a jogger, 10 m away from point P as shown in the above diagram and running at a constant speed of 2 m·s\(^{-1}\), sees the camera at the same instant it starts falling from the balloon, will he be able to catch the camera before it strikes the ground? Use a calculation to show how you arrived at the answer.  

(4)
Question 2 (Adapted from Feb/Mar 2011, P1, Question 3)

The velocity-time graph shown below represents the motion of two objects, A and B, released from the same height. Object A is released from REST and at the same instant object B is PROJECTED vertically upwards. (Ignore the effects of friction.)

2.1 Object A undergoes a constant acceleration. Give a reason for this statement by referring to the graph. (No calculations are required.) (2)

2.2 At what time/times is the SPEED of object B equal to 10 m·s⁻¹? (2)

2.3 What is the velocity of object A relative to object B at t = 1 s? (3)

2.4 Object A strikes the ground after 4 s. USE EQUATIONS OF MOTION to calculate the height from which the objects were released. (3)

2.5 What physical quantity is represented by the area between the graph and the time axis for each of the graphs A and B? (2)

2.6 Calculate, WITHOUT USING EQUATIONS OF MOTION, the distance between objects A and B at t = 1 s. (5)
**Question 3 (Adapted from Nov 2011, P1, Question 4)**

A patrol car is moving on a straight horizontal road at a velocity of 10 m·s\(^{-1}\) east. At the same time a thief in a car ahead of him is driving at a velocity of 40 m·s\(^{-1}\) in the same direction.

![Diagram showing the velocities of the patrol car and the thief's car relative to the ground.](image)

\[ v_{PG} = 10 \text{ m·s}^{-1} \quad v_{TG} = 40 \text{ m·s}^{-1} \]

\(v_{PG}\): velocity of the patrol car relative to the ground  
\(v_{TG}\): velocity of the thief’s car relative to the ground

3.1 Write down the velocity of the thief’s car relative to the patrol car. \(2\)

A person in the patrol car fires a bullet at the thief's car. The bullet leaves the gun with an initial horizontal velocity of 100 m·s\(^{-1}\) relative to the patrol car. Ignore the effects of friction.

3.2 Write down the initial velocity of the bullet relative to the thief's car. \(2\)

While travelling at 40 m·s\(^{-1}\), the thief's car of mass 1 000 kg, collides head-on with a truck of mass 5 000 kg moving at 20 m·s\(^{-1}\). After the collision, the car and the truck move together. Ignore the effects of friction.

3.3 State the law of conservation of linear momentum in words. \(2\)

3.4 Calculate the velocity of the thief's car immediately after the collision. \(6\)

3.5 Research has shown that forces greater than 85 000 N during collisions may cause fatal injuries. The collision described above lasts for 0.5 s. Determine, by means of a calculation, whether the collision above could result in a fatal injury. \(5\)
WORK ENERGY POWER

Check List
Make sure you can:
- Define work and use the equation to find work done
- Calculate the components of forces especially on an inclined plane
- State and use the work energy theorem to solve problems
- Define and calculate power

STUDY NOTES

Definition: Work done is energy transferred and it is measured in the unit of Joules. Work is not a vector but a scalar quantity. We don’t indicate direction for work.

Equation for Calculating Work
\[ W = F \cdot \Delta x \cdot \cos \theta \]
- When the force and change in position are in the same direction, the angle between these vectors is 0°. Since \( \cos 0 = 1 \), the work done is a maximum.
- When the force and change in position are in the opposite direction, the angle between these vectors is 180°. This gives a negative answer for the work done as the force will be a frictional force.
- When the force and change in position are at 90° to each other (perpendicular), no work is done (\( \cos 90° = 0 \)).

ENERGY

Energy is also a scalar quantity. Energy is the ability to do work and is also measured in Joules

Kinetic energy is the energy as a result of movement
\[ K = E_k = \frac{1}{2} mv^2 \]

Gravitational Potential Energy is the energy possessed as a result of position
\[ U = E_p = mgh \]

Mechanical Energy is a combination of kinetic and potential energies.

Mechanical Energy = Potential Energy + Kinetic Energy
\[ E_{\text{mech}} = U + K = E_p + E_k \]

Law of Conservation of Energy

Energy cannot be created nor destroyed. Energy can only be converted from one form to another.

During free fall, mechanical energy is conserved
\[ E_{\text{mech}} \text{ (initial)} = E_{\text{mech}} \text{ (final)} \]

Friction is a non-conservative force and where friction is present, mechanical energy is not conserved. The energy “lost” is due to the work done by the frictional force and may be converted into heat, sound, electrical energy or even light.
WORK-ENERGY THEOREM

The work done by a constant net force in displacing an object is equal to the change in kinetic energy of the object.

\[ W_{\text{net}} = \Delta E_k = F \Delta x \cos \theta \]

POWER

Power is also a scalar quantity. It is measured in the unit of Watts.

\[ P = \frac{\text{work done}}{\text{time}} = \frac{\text{energy transferred}}{\text{time}} \]

When a machine causes an object to move at **constant velocity** we can calculate the power of the machine by using the equation:

\[ P = F \cdot v \]

**Question 1** *(Adapted from Nov 2011, P1, Question 5)*

A rescue helicopter is stationary (hovers) above a soldier. The soldier of mass 80 kg is lifted vertically upwards through a height of 20 m by a cable at a **constant speed** of 4 m·s\(^{-1}\). The tension in the cable is 960 N. Assume that there is no sideways motion during the lift. Air friction is not to be ignored.

1.1 State the work-energy theorem in words. (2)

1.2 Draw a labelled free-body diagram showing ALL the forces acting on the soldier while being lifted upwards. (3)

1.3 Write down the name of a non-contact force that acts on the soldier during the upward lift. (1)

1.4 Use the WORK-ENERGY THEOREM to calculate the work done on the soldier by friction after moving through the height of 20 m. (5)
Question 2 (Adapted from Feb/Mar 2011, P1, Question 5)

A crate of mass 70 kg slides down a rough incline that makes an angle of 20° with the horizontal, as shown in the diagram below. The crate experiences a constant frictional force of magnitude 190 N during its motion down the incline. The forces acting on the crate are represented by R, S and T.

2.1 Label the forces R, S and T. (3)

2.2 Give a reason why force R does no work on the crate. (2)

The crate passes point A at a speed of 2 m·s⁻¹ and moves a distance of 12 m before reaching point B lower down on the incline.

2.3 Calculate the net work done on the crate during its motion from point A to point B. (5)

2.4 Write down the work-energy theorem in words. (2)

2.5 Use the work-energy theorem to calculate the speed of the crate at point B. (4)
Question 3 (Adapted from Feb/Mar 2009, P1, Question 6)

In South Africa the transportation of goods by trucks adds to the traffic problems on our roads. A 10 000 kg truck travels up a straight inclined road of length 23 m at a constant speed of 20 km·h⁻¹. The total work done by the engine of the truck to get there is 7 x 10⁵ J. The work done to overcome friction is 8.5 x 10⁴ J.

3.1 Calculate:
   3.1.1 The height, h, reached by the truck at the top of the road (6)
   3.1.2 The instantaneous power delivered by the engine of truck (6)

3.2 Arrestor beds are constructed as a safety measure to allow trucks to come to rest when their brakes fail whilst going downhill. Write down TWO design features of such arrestor beds. (2)
DOPPLER EFFECT

Check List
Make sure you can:
- Describe the Doppler Effect
- Use the Doppler Effect equation to solve problems

STUDY NOTES

Definition: The Doppler Effect occurs when the frequency of waves produced by a source is observed to be higher or lower than the actual frequency of the source.
  - The Doppler Effect can be observer using water waves, sound waves or light.

Facts about The Doppler Effect you must learn
- There must be relative motion between the source of waves and the observer.
- For Grade 12 examinations, one object will be stationary
- The most common example of the Doppler Effect is for sound waves
- For sound waves:
  - Increasing the frequency means the pitch increases
  - Decreasing the frequency means the pitch decreases
- When the observer moves towards the source or the source moves towards the observer, the frequency increases
- When the observer moves away from the source or the source moves away from the observer, the frequency decreases

The Doppler Effect Equation

\[ f_L = \frac{f_s (v \pm v_L)}{v \pm v_s} \cdot f_s \]

- \( f_L \) = frequency of the listener
- \( f_s \) = frequency of the source
- \( v_L \) = speed of the listener
- \( v_s \) = speed of the source
- \( v \) = speed of sound in the given medium

Although the equation looks complicated, it simply describes the relationship between the frequency of the listener and frequency of the source.

The part in brackets is a ratio of the velocities and can either be:
- a number bigger than 1 (source or listener are moving towards each other)
- equal to one
- a number smaller than 1 (source or listener are moving away from each other)
Question 1 (Adapted from Sept 2012, E.Cape, P1, Question 2.5 & 2.6)
Consider the diagram below for 1.1 & 1.2:

1.1 What does the diagram imply about the motion of the train?
A. The train is stationary.
B. The train moves towards Bibo.
C. The train moves towards Bonita.
D. The train is moving away from Bibo. (2)

1.2 The frequency and pitch of the sound heard by Bonita compared to that heard by Bibo is …
A. smaller sound frequency and lower pitch.
B. smaller sound frequency and higher pitch.
C. greater sound frequency and higher pitch.
D. greater sound frequency and lower pitch. (2)

Question 2 (Adapted from Nov 2011, P1, Question 6)
A train approaches a station at a constant speed of 20 m·s⁻¹ with its whistle blowing at a frequency of 458 Hz. An observer, standing on the platform, hears a change in pitch as the train approaches him, passes him and moves away from him.

2.1 Name the phenomenon that explains the change in pitch heard by the observer. (1)
2.2 Calculate the frequency of the sound that the observer hears while the train is approaching him. Use the speed of sound in air as 340 m·s⁻¹. (4)
2.3 How will the observed frequency change as the train passes and moves away from the observer? Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)
2.4 How will the frequency observed by the train driver compare to that of the sound waves emitted by the whistle? Write down only GREATER THAN, EQUAL TO or LESS THAN. Give a reason for the answer. (2)
Question 3 (Adapted from Feb/Mar 2012, P1, Question 6)

An ambulance approaches an accident scene at constant velocity. The siren of the ambulance emits sound waves at a frequency of 980 Hz. A detector at the scene measures the frequency of the emitted sound waves as 1 050 Hz.

3.1 Calculate the speed at which the ambulance approaches the accident scene.
   Use the speed of sound in air as 340 m·s⁻¹.  
   (4)

3.2 Explain why the measured frequency is higher than the frequency of the source.  
   (2)

3.3 The principle of the Doppler effect is applied in the Doppler flow meter. State ONE positive impact of the use of the Doppler flow meter on humans.  
   (2)

Question 4 (Adapted from Nov 2008, P1, Question 8)

An ambulance travelling down a road at constant speed emits sound waves from its siren. A lady stands on the side of the road with a detector which registers sound waves at a frequency of 445 Hz as the ambulance approaches her.

After passing her, and moving away at the same constant speed, sound waves of frequency 380 Hz are registered. Assume that the speed of sound in air is 343 m·s⁻¹.

4.1 Name the phenomenon that describes the change in the frequency observed by the lady.  
   (1)

4.2 Calculate:
   4.2.1 The speed at which the ambulance is moving  
   (7)
   4.2.2 The frequency at which the siren emits the sound waves  
   (3)
ELECTROSTATICS & ELECTRIC CIRCUITS

Check List
Make sure you can:
- Describe and draw a sketch of an electric field around different charged particles
- State and apply the Law of Conservation of Charge, Coulomb’s Law and Ohm’s Law
- Define and calculate Electric Field Strength produced by a charged object and between parallel plates.
- Recall the function of a capacitor, the factors that affect capacitance and how to calculate capacitance.
- Perform calculations for electric circuits that have resistors in series and parallel and cells with internal resistance.
- Calculate how energy is transferred in an electric circuit.

STUDY NOTES

Electric Fields
- An electric field is a region in space in which an electric charge will experience a force represented by a pattern of field lines.

Conservation of Charge
The Law of Conservation of Charge states that charges cannot be created nor destroyed but are merely transferred from one object to another, i.e. the amount of charges in a closed system remains the same.

Use the equation below to calculate the charge on two spheres that are brought into contact and then separated:

\[ Q_{\text{new}} = \frac{(Q_A+Q_B)}{2} \]

Coulomb’s Law of Electrostatics
The Coulomb’s Law states that the force of attraction or repulsion between the two electric charges at rest is directly proportional to the product of the charges, and inversely proportional to the square of the distance between them.

\[ F = \frac{k Q_1 Q_2}{r^2} \]

Q = charge, unit: coulomb (C) \( r \) = distance between the charges, measured in m
k = Coulomb’s constant = \( 9 \times 10^9 \) N·m²·C⁻²
CAPACITORS

- A **capacitor** is a device that can store energy.
- Inside a capacitor the terminals connect to two metal plates that are separated by an insulating material called a **dielectric**. The dielectric can be anything that does not conduct electricity readily and it keeps the plates from touching each other.
- The bigger the area of the plates, the more charge the capacitor can store.
- Symbol: \[ \frac{1}{C} \]

Four factors affect the ability of the capacitor to store electrical charge. These are:
- The potential difference between the plates
- The area of the plates
- The distance between the plates
- The insulating substance between the parallel plates.

Capacitance

- **Capacitance** is a measure of the ability of a capacitor to store charge.
- The capacitance (C) of a capacitor is the charge stored on its plates per volt of potential difference between the plates.
  \[ C = \frac{Q}{V} \]
- The units for capacitance is coulomb per volt (C.V\(^{-1}\)) called a **farad** (F).

ELECTRIC CIRCUITS

Resistance and Ohm's Law

*Ohm's Law states that the current between any two points in a conductor is directly proportional to the potential difference between these points provided that the temperature of the conductor remains constant.*

Equation: \[ R = \frac{V}{I} \]

Units: current – amperes (A), voltage – volts (V) and resistance – ohms (Ω)
- The resistance of the conductor depends on:
  - The type of material used
  - The length of the conductor – the longer the conductor, the greater the resistance
  - The thickness of the conductor – the thicker the conductor, the smaller the resistance
  - The temperature of the conductor – the higher the temperature, the greater the resistance
Series and Parallel Connections

<table>
<thead>
<tr>
<th>Components</th>
<th>Connection</th>
<th>Diagram</th>
<th>Current (A)</th>
<th>Potential Difference (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistors</td>
<td>Series</td>
<td><img src="image" alt="Series Diagram" /></td>
<td>The current in a given series circuit is the same throughout the circuit. The more resistors in series, the greater the resistance; the current decreases.</td>
<td>Resistors in series are potential dividers, i.e. ( V_T = V_1 + V_2 )</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Parallel</td>
<td><img src="image" alt="Parallel Diagram" /></td>
<td>Resistors in parallel have the same potential (in the absence of another resistor in series).</td>
<td>Resistors in parallel in a given circuit split the current. ( A_T = A_1 + A_2 ) (the more resistors in parallel, the greater the total current because the total resistance decreases.)</td>
</tr>
</tbody>
</table>
EMF and Internal Resistance

- The emf of a cell is the maximum amount of energy which the cell can supply.
- We measure the emf of a cell or battery by connecting a voltmeter across the terminals. The battery may be connected to an open circuit.
- When the cell is delivering current to a circuit (closed circuit), the terminal potential difference is less than the emf; the difference is called ‘lost volts’ or internal volts.
- The reason there is a difference between the emf and potential difference across the terminals of a battery in a closed circuit, is that there is an internal resistance inside each cell.

Equation

\[ \text{emf} = \text{terminal potential difference} + \text{“lost volts”} \]
\[ \text{Emf} = \text{IR} + \text{Ir} \]
\[ \text{Emf} = I(R + r) \]

Energy in an Electric Circuit

Potential difference in an electric field

- Potential difference
  \[ V = \frac{W}{Q} \]
- Quantity of charge:
  \[ Q = I \Delta t \]
- Work done by an electric field:
  \[ W = V I \Delta t \]

Power: the rate at which work is done

\[ \text{Power} = \frac{\text{work}}{\text{Time}} \]
Units: watt (W)

Electrical Power: \[ P = V I \] or \[ P = I^2R \] or \[ P = \frac{V^2}{R} \]
**Electrostatics & Electric Circuits Questions**

**Question 1**  (Adapted from November 2011 P1, Question 8)

Two metal spheres, P and T, on insulated stands, carry charges of +3 x 10^-9 C and -6 x 10^-9 C respectively.

![Diagram of spheres P and T with charges indicated](image)

The spheres are allowed to touch each other and are then placed 1.5 m apart as shown below.

![Diagram showing spheres P and T 1.5 m apart](image)

1.1 In which direction will electrons flow while spheres P and T are in contact? Write down only FROM P TO T or FROM T TO P.  

1.2 Calculate the net charge gained or lost by sphere P after the spheres have been in contact.  

1.3 Calculate the number of electrons transferred during the process in QUESTION 1.2.  

A third sphere R, carrying a charge of -3 x 10^-9 C, is NOW placed between P and T at a distance of 1 m from T.

1.4 Calculate the net force experienced by sphere R as a result of its interaction with P and T.
Question 2

2.1 Capacitors are widely used in common household electrical appliances like television screens, computers, alarm systems etc.

2.1.1 What is the function of a capacitor in an electrical appliance. (2)

2.1.2 A specific capacitor stores a maximum of 30 nC of charge at a potential difference of 12 V across the ends. Calculate the capacitance of this capacitor. (3)

2.1.3 During an electrical thunderstorm the potential difference between the earth and the bottom of the clouds can be 35 000 kV. If the surface area of the clouds is $1 \times 10^8$ m$^2$ at a height of 1 200 m above the surface of the earth, calculate the capacitance of this gigantic “earth-cloud” capacitor. Take the permittivity of air to be the same as the permittivity of a vacuum. (4)

Question 3 (Adapted from November 2011 P1, Question 9)

Learners conduct an investigation to verify Ohm’s law. They measure the current through a conducting wire for different potential differences across its ends. The results obtained are shown in the graph below.

3.1 Which ONE of the measured quantities is the dependent variable? (1)

3.2 The graph deviates from Ohm’s law at some point.

3.2.1 Write down the coordinates of the plotted point on the graph beyond which Ohm’s law is not obeyed. (2)

3.2.2 Give a possible reason for the deviation from Ohm’s law as shown in the graph. Assume that all measurements are correct. (2)

3.3 Use the graph to calculate the resistance of the resistor. (4)
Question 4
The circuit on the following page shows a battery consisting of four 1.5 V cells connected in series. An ammeter with negligible resistance is connected in series to the battery. The reading on the ammeter is 0.5 A when the switch is closed. The connectors have negligible resistance and the voltmeters have very high resistance. Voltmeter $V_1$ has a reading of 5.5 V when the switch is closed.

4.1 Calculate the value of the internal resistance of a single cell. (4)
4.2 Calculate the value of the resistance of the external circuit. (4)
4.3 Calculate the value of the reading on voltmeter $V_2$ (4)

[12]
ELECTRODYNAMICS

Check List
Make sure you can:
- Explain how a motor and a generator works
- Describe the components of these electric machines and explain the function of each
- State what factors will affect the speed of a motor or the emf of a generator
- Compare direct current (d.c) and alternating current (a.c)
- Draw graphs and complete calculations for alternating current

STUDY NOTES
There are two electrical machines that you need to know about:
- The Electric Motor (Supply electrical energy → produce mechanical energy)
- The Electric Generator (Supply mechanical energy → produce electrical energy)

The Electric Motor
In an electric motor, an electric current passes through a coil in a magnetic field. The combination of the two force fields produces a torque (rotation) which turns the coil of the motor. The split ring commutator reverses the current each half turn to keep the coil turning in the same direction. The brushes on the commutator allow for the free rotation of the coil.
If we want to maximise the force created by the motor effect we can:
- Make the current stronger
- Increase the strength of the magnetic field
- Make sure that the angle between the magnetic field direction and the direction of the current is as close to 90º as possible, since the maximum effect is when the current flows at 90º to the magnetic field lines.

The Electric Generator (Dynamo)
The generator illustrates the principle of electromagnetic induction:

Faraday’s Law of Induction
The induced emf in a conductor is directly proportional to the rate of change of the magnetic flux through the conductor.
There are two types of generators:
A DC generator: Same structure as a motor but the coil is turned and produces Direct Current (D>C). This machine has a split ring commutator.
An AC Generator (Dynamo): This machine has slip rings and produces alternating current
Alternating current

Our power stations produce alternating current and the current that we get from the plug points in our homes is AC. The frequency of alternating current in South Africa is 50Hz. The graph below shows how the current changes direction every half revolution, and is changing strength continually as the coil rotates in the magnetic field.

![Graph showing alternating current changes](image)

Advantages of AC

We can use transformers to step up the voltage and step down the current. This enables the distribution of on the national power grid with low energy loss.

Calculations for AC

The potential difference varies between 0V and 311V. This has the same effect as a constant value of 220V. We call this the root mean square voltage

\[
V_{\text{RMS}} = \frac{V_{\text{max}}}{\sqrt{2}}
\]

The current also fluctuates with time:

\[
I_{\text{RMS}} = \frac{I_{\text{max}}}{\sqrt{2}}
\]

The average power in an AC circuit is calculated by using:

\[
P_{\text{ave}} = V_{\text{RMS}} I_{\text{RMS}}
\]

\[
P_{\text{ave}} = I_{\text{RMS}}^2 R
\]

\[
P_{\text{ave}} = V_{\text{RMS}}^2 + R
\]
**Electrodynamics Questions**

**Question 1**  
Electric motors are important components of many modern electrical appliances. AC motors are used in washing machines and vacuum cleaners, and DC motors are used in toys and tools.

1.1 What energy conversion takes place in electric motors?  

1.2 What is the essential difference in the design between DC and AC motors?  

1.3 List THREE ways in which the efficiency of the motor can be improved.  

1.4 Consider the diagram below. The conventional current flows in the direction indicated by the arrows.

---

1.4.1 In which direction (clockwise or anti-clockwise), as seen from position A, will the coiled armature rotate if the switch is closed?  

1.4.2 Why does the armature continue moving in the same direction once it has reached the vertical position?
Question 2
The simplified sketch below shows the principle of operation of the alternating current (AC) generator.

2.1 Name the parts labelled A and B respectively. (2)

2.2 In which direction does segment PQ of the coil have to be rotated in order to cause the current direction as shown in the diagram? Write down only clockwise or anticlockwise. (1)

2.3 Write down TWO changes that can be brought about to improve the output of the generator. (2)

2.4 What changes must be made to the AC generator to make it function as a DC motor? (2)

Question 3 (Adapted from November 2011 P1, Question 11)
Diesel-electric trains make use of electric motors as well as generators.

3.1 The table below compares a motor and a generator in terms of the type of energy conversion and the underlying principle on which each operates. Complete the table by writing down only the question number (11.1.1–11.1.4) in the ANSWER BOOK and next to each number the answer.

<table>
<thead>
<tr>
<th></th>
<th>TYPE OF ENERGY CONVERSION</th>
<th>PRINCIPLE OF OPERATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor</td>
<td>3.1.1</td>
<td>3.1.3</td>
</tr>
<tr>
<td>Generator</td>
<td>3.1.2</td>
<td>3.1.4</td>
</tr>
</tbody>
</table>
The simplified diagram below represents an electric motor.

3.2 Give a reason why the section of the coil labelled BC in the above diagram does not experience a magnetic force whilst the coil is in the position as shown.

3.3 Graphs of the current and potential difference outputs of an AC generator are shown below.

![Graphs of current and potential difference](image)

Calculate the average power output of this generator.

(2)

(6)
Question 4

The waveform on the following page is a graphical representation of the variation of voltage (V) versus time (t) for an alternating current.

3.1 Explain the advantage of using alternating current at power stations. (2)

3.2 Calculate the average power dissipated by this generator if the rms current produced is 13A. (5)

[Diagram of alternating current waveform]
ELECTROMAGNETIC RADIATION

Check List
Make sure you can:

- Describe the parts of the electromagnetic spectrum and how we use them
- Use the wave equation to calculate frequency or wavelength
- Describe the energy relationships for different types of radiation
- Explain and calculate diffraction of light when passing through a single slit
- Explain and describe the Photoelectric Effect
- Calculate the work function, threshold frequency and kinetic energy of photoelectrons

STUDY NOTES

Electromagnetic waves can be set up by charges that oscillate backwards and forwards. The oscillation causes a vibration which in turn causes a wave shaped electric field. As the electric field changes, it induces (creates) a changing magnetic field at right angles to it. As the magnetic field changes, it induces a changing electric field at right angles to it. It this way the wave self propagates (keeps on going).

The magnetic and electric fields are in phase with one another.

Electromagnetic waves are transverse waves.

Electromagnetic waves do not need a physical medium to travel in. They can travel through a vacuum.

All electromagnetic waves travel at a speed $c = 3 \times 10^8$ m.s$^{-1}$ (in a vacuum)

$$v = c = f \times \lambda$$

THE ELECTROMAGNETIC SPECTRUM

There are different types of electromagnetic waves which we arrange in order of increasing frequency in spectrum:


PROPERTIES OF LIGHT
SPECTRA
There are three types of spectra you need to be able to explain:

- **Visible spectrum**
  When visible white light is refracted through a prism, we see the colour of the different frequencies of light (colours of the rainbow).

- **Line emission spectrum**
  When energy is given to any element in its gas phase, it will radiate light of certain frequencies. When this light is refracted through a prism, a unique pattern of lines appears for each element. These lines correspond to the energy levels of electrons in the atoms that have been excited.

- **Line absorption spectra**
  A line absorption spectrum is formed when white light is passed through a cold gas (element) and then passed through a prism. We see a continuous spectrum but with a unique pattern of black lines. The black lines represent frequencies of light that have been absorbed by the gas.

**Diffraction of Light**
When light of a single frequency passes through a small slit, a diffraction pattern will form as shown below:

Equation for Calculating the Angle of Diffraction, $\theta$

$$\sin \theta = \frac{m\lambda}{a}$$

$\theta$ = angle of diffraction (between the normal to the slit and the dark fringes).
$d$ = width of slit (m).
$\lambda$ = wavelength of light (m).
$m$ = the number (+1, +2, +3 etc) of the dark band from the centre of the diffraction pattern.

**Young’s Double Slit Experiment**

When light of the same frequency (colour) passes through two narrow slits close to each other, a pattern of evenly spaced bright and darker bands can be projected onto a screen. The bright bands are formed as a result of constructive interference, while the darker bands are a result of destructive interference. This experiment confirms that light has wave properties.

**Interference: The Principle of Superposition**

The magnitude of the resultant displacement is the algebraic sum of the displacements of the pulses before interference occurs.

In other words: When two waves meet, they interact with one another.

- When two peaks meet, they make a larger peak equal in amplitude to the size of the sum of the amplitudes of the original two waves. This is constructive interference or an anti-node.
- When two troughs meet, they make a larger trough equal in amplitude to the size of the sum of the amplitudes of the original two waves. This is constructive interference or an anti-node.
- When a peak and a trough meet, they make a smaller peak or trough equal in amplitude to the size of the difference between the amplitudes of the original two waves. This is destructive interference or a node.

**Photoelectric Effect**

When light of high enough energy collides with an electron near the surface of a metal, it transfers all its energy to the electron. If the electron gains enough energy, it is knocked off the metal surface.

Wave theory relates the energy of the wave to amplitude (intensity / loudness). Increasing the brightness of a red light does not knock off electrons from the surface of a metal but a dim ultraviolet light does. Wave theory of light cannot explain this result.

Planck suggested that energy was quantised and depended on frequency. Einstein applied Planck’s ideas to light and proposed that light consists of particles called photons. The energy of the photon (a packet of energy) is given by the equation:

$$E = hf$$

$h$ = Plank’s constant ($6.6 \times 10^{-34} \text{ J}\cdot\text{s}$)
Different metal surfaces require different amounts of energy to release an electron. The minimum amount of energy required is called the work function of the metal ($W_0$) and this corresponds to the threshold frequency of the photon ($f_0$). When the energy of the photon is greater than the work function, the electrons knocked off the surface of the metal gain kinetic energy too. Hence the equation for the photoelectric effect is:

$$ E = h.f = W_0 + E_k = h.f_0 + \frac{1}{2} m v^2 $$

Increasing the brightness (intensity) of a source of light increases the number of photons released and will increase the number of electrons knocked off if the photons have enough energy. The photoelectric effect gives evidence that the light has a particle nature.

**Duality of Light**

Light has both a wave nature and a particle nature at the same time.

**Question 1**

1.1  *(Adapted from Nov 2011, P1, Question 2.10)*

Which ONE of the following electromagnetic waves has the shortest wavelength?

A  Radio waves  
B  Gamma rays  
C  Infrared rays  
D  Ultraviolet rays  

(2)

1.2  *(Adapted from Feb/Mar 2012, P1, Question 2.10)*

Overexposure to sunlight causes damage to plants and crops. Which ONE of the following types of electromagnetic radiation is responsible for this damage?

A  Ultraviolet rays  
B  Radio waves  
C  Visible light  
D  X-rays  

(2)

1.3  *(Adapted from Nov 2011, P1, Question 2.9)*

Which ONE of the following descriptions best explains the formation of a line emission spectrum? A line emission spectrum is formed when …

A  white light passes through a cold gas.  
B  white light passes through a triangular prism.  
C  electrons in the ground state move to a higher energy level.  
D  electrons in the excited state move to a lower energy level.  

(2)
1.4  (Adapted from Feb/Mar 2012, P1, Question 2.5)

Monochromatic light from a point source passes through a device X. A pattern is observed on a screen, as shown in the diagram below.

From the observation on the screen, it can be concluded that device X is a …

A  prism.
B  single slit.
C  double slit.
D  concave lens.  

(2)

1.5  (Adapted from Feb/Mar 2012, P1, Question 2.9)

When light shines on a metal plate in a photocell, electrons are emitted. The graph below shows the relationship between the kinetic energy of the emitted photoelectrons and the frequency of the incoming light.

Which ONE of the points (A, B, C or D) on the graph represents the threshold frequency?

A  A  
B  B  
C  C  
D  D  

(2)
A learner investigates the change in broadness of the central bright band in a diffraction pattern when light passes through single slits of different widths. She uses monochromatic violet light of wavelength $4 \times 10^{-7}$ m. The apparatus is set up as shown in the diagram below.

**Question 2 (Adapted from Nov 2011, P1, Question 7)**

2.1 Define the term *monochromatic light* (2)

2.2 Write down the investigative question for this investigation. (2)

2.3 Write down TWO variables that are kept constant during this investigation. (2)

2.4 The learner now uses a narrower slit. How will the broadness of the central bright band change? Write down only INCREASES, DECREASES or REMAINS THE SAME. Give an explanation. (2)

2.5 Calculate the angle $\theta$ at which the second minimum is formed if a slit of width $2.2 \times 10^{-6}$ m is used. (5)
A metal surface is illuminated with ultraviolet light of wavelength 330 nm. Electrons are emitted from the metal surface.

The minimum amount of energy required to emit an electron from the surface of this metal is \(3.5 \times 10^{-19}\) J.

3.1 Name the phenomenon illustrated above. (1)

3.2 Give ONE word or term for the underlined sentence in the above paragraph. (1)

3.3 Calculate the frequency of the ultraviolet light. (4)

3.4 Calculate the kinetic energy of a photoelectron emitted from the surface of the metal when the ultraviolet light shines on it. (4)

3.5 The intensity of the ultraviolet light illuminating the metal is now increased. What effect will this change have on the following:

3.5.1 Kinetic energy of the emitted photoelectrons (Write down only INCREASES, DECREASES or REMAINS THE SAME.) (1)

3.5.2 Number of photoelectrons emitted per second (Write down only INCREASES, DECREASES or REMAINS THE SAME.) (1)

3.6 Overexposure to sunlight causes damage to skin cells.

3.6.1 Which type of radiation in sunlight is said to be primarily responsible for this damage? (1)

3.6.2 Name the property of this radiation responsible for the damage. (1)
SOLUTIONS TO VERTICAL PROJECTILE MOTION & MOMENTUM

Question 1 (Adapted from Nov 2011, P1, Question 3)

1.1 The initial velocity / speed of the camera is the same (as that of the balloon).

1.2 **Downward negative:**

\[ \Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2 \]

\[ \therefore -92.4 = v_i(6) + \frac{1}{2}(-9.8)(6)^2 \]

\[ \therefore v_i = 14 \text{ m·s}^{-1} \text{ upwards} \]

1.3

\[ \Delta x = v \Delta t \]

\[ \therefore 10 = (2) \Delta t \]

\[ \therefore \Delta t = 5 \text{ s} \]

Yes The jogger will catch the camera, the time to run is less than 6 s (time for camera to fall).
Question 2 (Adapted from Feb/Mar 2011, P1, Question 3)

2.1 Gradient of the graph is constant.

2.2 At t = 1 s and t = 3 s

2.3 \( V_{AB} = V_{AC} + V_{CB} \)
   \[ = -10 + (-10) \]
   \[ = -20 \text{ m·s}^{-1} \]
   = 20 m·s\(^{-1}\) downwards

2.4 \( \Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2 \)
   \[ = (0)(4) + \frac{1}{2}(10)(4)^2 \]
   (Value of \( a = 10 \) comes from the gradient of the graph)
   = 80 m (78.4 m if \( a = 9.8 \text{ m·s}^{-2} \) – must use this value unless told to read from graph)

2.5 Change in position / displacement

2.6

\[ \begin{align*}
\text{Distance covered by object B} \\
\Delta y = \frac{1}{2} bh + lb \\
= \frac{1}{2} (1)(10) + (10)(1) \\
= 15 \text{ m}
\end{align*} \]

\[ \text{Distance covered by object A} \\
\Delta y = \frac{1}{2} bh \\
= \frac{1}{2} (1)(-10) \checkmark \text{ Accept: } \frac{1}{2} (1)(10) \\
= -5 \text{ m} \\
= 5 \text{ m}
\]

Distance between A and B = 15 – (-5) = 20 m \checkmark

Accept:
Distance between A and B = 15 + (5) = 20 m \checkmark

Question 3 (Adapted from Nov 2011, P1, Question 4)

3.1 30 m·s\(^{-1}\) east

3.2 \( v_{BT} = v_{BP} + v_{PG} + v_{GT} \)
   \[ = 100 + 10 + (-40) \]
   \[ = 70 \]
   \[ \therefore v_{BT} = 70 \text{ m·s}^{-1} \text{ east} \]

3.3 The total (linear) momentum remains constant in an isolated system
3.4 To the right as positive:
\[ \Sigma p \text{ (before)} = \Sigma p \text{ (after)} \]
\[ (1\,000)(40) + (5\,000)(-20) = (1\,000 + 5\,000)v_f \]
\[ \therefore v_f = -10 \text{ m·s}^{-1} \]
\[ \therefore v_f = 10 \text{ m·s}^{-1} \text{ left OR west} \]

3.5 Force on car: To the right as positive
\[ F_{net} \Delta t = \Delta p = mv_f - mvi \]
\[ F_{net}(0,5) = 1\,000(-10 – 40) \]
\[ \therefore F_{net} = -1 \times 10^5 \text{ N} \]
\[ \therefore F_{net} = 1 \times 10^5 \text{ N (100 000 N)} \text{ to the left} \]
\[ \therefore F_{net} > 85\,000 \text{ N} \text{ Yes, collision is fatal.} \]

**SOLUTIONS TO WORK ENERGY POWER**

**Question 1 (Adapted from Nov 2011, P1, Question 5)**

1.1 The net (total) work done on an object is equal to the change in kinetic energy of the object.

1.2

\[ FA_{\text{Applied}} = \text{Force of the cable on the soldier} \]

\[ f = \text{force of air friction on the soldier} \]

\[ W = \text{weight of the soldier = force of the Earth on the soldier} \]

1.3 Gravitational force or weight

1.4

\[ W_{\text{net}} = \Delta K \]
\[ F\Delta y\cos \theta + F_w\Delta y\cos \theta + W_f = \Delta K \]
\[ (960)(20)\cos 0^\circ + (80)(9.8)(20)\cos 180^\circ + W_f = 0 \]
\[ 19\,200 - 15\,680 + W_f = 0 \]
\[ W_f = -3\,520 \text{ J} \]
Question 2 (Adapted from Feb/Mar 2011, P1, Question 5)

2.1 R: Force of incline (surface) on crate / N / Normal (force) / FN
S: Gravitational force / Gravity / force of Earth on crate / F_g / W / F_{Earth on crate}
T: Frictional force / F_f / F_{friction} / f

2.2 The force is perpendicular to the displacement of the crate.

\[ W = F \Delta x \cos 90^\circ = 0 \]

2.3 \[ W_{net} = W_{\parallel} + W_f \]
\[ = mg \sin 20^\circ \Delta x \cos 0^\circ + f \Delta x \cos 180^\circ \]
\[ = (70)(9.8)\sin 20^\circ (12)\cos 0^\circ + (190)(12)\cos 180^\circ \]
\[ W_{net} = 535.51 \text{ J} \]

2.4 The net (total) work done on an object is equal to the change in kinetic energy of the object.

2.5 \[ W_{net} = \Delta K \]
\[ 535.51 = \frac{1}{2} m(v_f^2 - v_i^2) \]
\[ 535.51 = \frac{1}{2} (70)(v_f^2 - 4) \]
\[ v_f = 4.39 \text{ m/s} \]

Question 3 (Adapted from Feb/Mar 2009, P1, Question 6)

3.1.1
\[ W_{net} = \Delta E_p + \Delta E_k \]
\[ \therefore W_{net} = (mgh_f - mgh_i) + \left( \frac{1}{2} mv_i^2 - \frac{1}{2} mv_f^2 \right) \]
\[ \therefore 7 \times 10^5 \checkmark = 8.5 \times 10^4 \checkmark = 10000(9.8)(h_f - 0) \checkmark + 0 \checkmark \]
\[ \therefore 6.15 \times 10^5 = 10000(9.8)h_f \]
\[ \therefore h_f = 6.28 \text{ m} \checkmark \]

3.1.2
\[ W = F \Delta x \cos \theta \checkmark \]
\[ \therefore 7 \times 10^5 = F(23)(1) \checkmark \]
\[ \therefore F = 3.04 \times 10^4 \text{ N} \checkmark \]

\[ P = Fv \checkmark \]
\[ = (3.04 \times 10^4)(\frac{20000}{60 \times 60}) \checkmark \]
\[ = 1.6 \times 10^5 \text{ W} \checkmark \]

3.2 Surface must provide sufficient friction like sand
Must be long enough for vehicle to stop.
**SOLUTIONS TO DOPPLER EFFECT**

**Question 1** *(Adapted from Sept 2012, E.Cape, P1, Question 2.5 & 2.6)*

1.1 B  **Reason:** The wavelength is shorter near Bibo and longer near Bonita

1.2 A  **Reason:** Sound waves with longer wavelengths have higher frequency and higher pitch.

**Question 2** *(Adapted from Nov 2011, P1, Question 6)*

2.1 Doppler Effect

2.2

\[ f_L = \frac{v \pm v_L}{v \pm v_s} f_s \]

\[ \therefore f_L = \frac{340 + 0}{340 - 20} \quad (458) \checkmark \]

\[ \therefore f_L = 486.63 \, \text{Hz} \checkmark \]

2.3 Decreases

2.4 Equal to

Velocity of train driver relative to the whistle is zero.

**Question 3** *(Adapted from Feb/Mar 2012, P1, Question 6)*

3.1

\[ f_L = \frac{v \pm v_L}{v \pm v_s} f_s \quad \text{OR} \quad f_L = \frac{v}{v - v_s} f_s \checkmark \]

\[ \therefore 1050 \checkmark = \frac{340 + 0}{340 - v_s} (980) \checkmark \]

\[ \therefore v_s = 22.67 \, \text{m/s}^{-1} \checkmark \]

3.2 Waves in front of the moving source are compressed. The observed wavelength decreases. For the same speed of sound, a higher frequency will be observed.

3.3 Determine whether arteries are clogged so that precautions can be taken in advance/to prevent heart attack /stroke.

\text{or}

Determine heartbeat of foetus to assure that child is alive/does not have a heart defect.
Question 4 (Adapted from Nov 2008, P1, Question 8)

4.1 Doppler Effect

4.2.1

\[ f_L = \frac{V \pm V_L}{V \pm V_s} f_s \]

Approach: \[ f_L = \frac{V \pm V_L}{V - V_s} f_s \]

Move away: \[ f_L = \frac{V \pm V_L}{V + V_s} f_s \]

Ambulance approaching

\[ 445 = f_s \frac{343}{343 - V_s} \]  
\[ \therefore 445(343 - V_s) = 343f_s \]  
\[ \text{(i)} \]

Ambulance moving away

\[ 380 = f_s \frac{343}{343 + V_s} \]  
\[ \therefore 380(343 + V_s) = 343f_s \]  
\[ \text{(ii)} \]

\[ 445(343 - V_s) = 380(343 + V_s) \]  
\[ V_s = 27.02 \text{ m} \cdot \text{s}^{-1} \]

4.2.2

\[ 445 = f_s \frac{343 \pm 0}{343 - V_s} \]  
\[ \therefore 445(343 - 27.02) = 343f_s \]  
\[ f_s = 409.94 \text{ Hz} \]
SOLUTIONS TO ELECTROSTATICS & ELECTRIC CIRCUITS

Question 1

1.1 T to P

1.2 \[ Q = (3 \times 10^{-9} + (-6 \times 10^{-9})) + 2 = -1.5 \times 10^{-9} \text{ C} \]

\[ \Delta QP = QP(\text{final}) - QP(\text{initial}) \]
\[ = -1.5 \times 10^{-9} - 3 \times 10^{-9} \]
\[ = -4.5 \times 10^{-9} \text{ C} \]

1.3 Number of electrons = \((- 4.5 \times 10^{-9}) + (-1.6 \times 10^{-19})\)

1.4 \[ F_{TR} = \frac{KQ_1Q_2}{r^2} \]
\[ = \frac{(9 \times 10^9)(1.5 \times 10^{-9})(3 \times 10^{-9})}{1^2} \]
\[ = 4.05 \times 10^{-8} \text{ N to the left / towards P} \]

\[ F_{PR} = \frac{KQ_1Q_2}{r^2} \]
\[ = \frac{(9 \times 10^9)(1.5 \times 10^{-9})(3 \times 10^{-9})}{(0.5)^2} \]
\[ = 1.62 \times 10^{-7} \text{ N to the right / towards T} \]

Let the direction to the right (towards T) be positive

\[ F_{\text{net}} = 1.62 \times 10^{-7} + (-4.05 \times 10^{-8}) \]
\[ = 1.22 \times 10^{-7} \text{ N to the right} \]

Question 2

2.1.1 It stores electrical charge OR electric potential energy ✓✓

2.1.2 \[ C = \frac{Q}{V} = \frac{30 \times 10^{-9}}{12} = 2.5 \times 10^{-9} \text{ F} (= 2.5\mu\text{F}) ✓✓ \]

2.1.3 \[ C = \frac{\epsilon_0 A}{d} = \frac{(8.85 \times 10^{-12})(1 \times 10^8)}{1200} = 1.06F \hspace{1cm} ✓✓ \]

Question 3

3.1 Current

3.2.1 (4; 0)
3.2.2 Temperature was not kept constant.       (2)

3.3 Gradient = \( \frac{\Delta y}{\Delta x} = \frac{0.64-0}{4-0} \)

= 0,16

\[ \therefore R = \frac{1}{0,16} \]  

Question 4

4.1

\[ r_{\text{battery}} = \frac{V_{\text{usedinbattery}}}{I_{\text{total}}} = \frac{0.5}{0.5} = 1\Omega \quad \text{thus each cell} \quad = 1\Omega/4 = 0.25\Omega \]  

(4)

4.2

\[ \frac{1}{R_p} = \frac{1}{6+4} + \frac{1}{15} = \frac{1}{6} \quad \text{so} \quad R_p = 6\Omega \quad \text{and} \]

\[ R_{\text{external}} = r_1 + r_2 = 5 + 6 = 11\Omega \]

OR

\[ R_{\text{external}} = \frac{V_{\text{external}}}{I_{\text{total}}} = \frac{5.5}{0.5} = 11\Omega \]  

(4)

4.3

\[ V_{5\Omega} = IR = 0.5(5) = 2.5V \quad \text{thus} \]

\[ V_2 = 5.5 - 2.5 = 3\text{ V} \quad \checkmark \]

OR

\[ V_2 = I_{\text{total}}R_p = 0.5(6) = 3\text{ V} \quad \checkmark \]  

(4)
SOLUTIONS TO ELECTRODYNAMICS

Question 1

1.1 Electrical energy √ converted to rotational mechanical energy. √  (2)

1.2. A DC motor reverses current direction with the aid of the commutator whenever the coil is in the vertical √ position to ensure continuous rotation.

An AC motor, with alternating current as input, works without commutators since the current alternates. √  (2)

1.3 Increase the number of turns on each coil/increased number of coils √

Stronger magnets √

Bigger current √  (3)

1.4.1 Clockwise √  (1)

1.4.2 Its own momentum, √ split ring commutator changes direction √ of current, every time the coil reaches the vertical position.  (2)

Question 2

2.1 A = slip rings √

B = brushes √  (2)

2.2 anti-clockwise √  (1)

2.3 Any two:

Increase the number of turns of the coil √

Increase the magnetic field strength (stronger magnets) √

Increase speed of rotation

Use horse-shoe magnet –(it helps to concentrate the field)  (2)

2.5 Use split ring commutators instead of slip rings. √

Add a battery to provide electrical energy to drive motor. √  (2)

Question 3 (Adapted from November 2011 P1, Question 11)

3.1.1 Electrical (energy) to mechanical / kinetic (energy) √

3.1.2 Mechanical / kinetic (energy) to electrical (energy) √

3.1.3 Motor effect √

3.1.4 Electromagnetic induction √  (4)

3.2 BC / conductor is parallel √ to the magnetic field. √

 OR / OF

Open switch √, no current. √  (2)
3.3

**Option 1 / Opsie 1:**

\[ P_{\text{ave}} = V_{\text{rms}}I_{\text{rms}} \]

\[ = \frac{V_{\text{max}}}{\sqrt{2}} \cdot \frac{I_{\text{max}}}{\sqrt{2}} \]

\[ = \frac{(311)(21)}{2} \]

\[ = 3 265,5 \text{ W} \]

**Option 2 / Opsie 2:**

\[ V_{\text{rms}} = \frac{V_{\text{max}}}{\sqrt{2}} \]

\[ = \frac{311}{\sqrt{2}} \]

\[ = 219,91 \text{ V} \]

\[ I_{\text{rms}} = \frac{I_{\text{max}}}{\sqrt{2}} \]

\[ = \frac{21}{\sqrt{2}} \]

\[ = 14,85 \text{ A} \]

\[ P_{\text{ave}} = V_{\text{rms}}I_{\text{rms}} \]

\[ = (219,91)(14,85) \]

\[ = 3 265,66 \text{ W} \]

**OR / OF**

\[ P_{\text{max}} = V_{\text{max}}I_{\text{max}} \]

\[ = (311)(21) \]

\[ = 6531 \text{ W} \]

\[ : P_{\text{ave}} = \frac{P_{\text{max}}}{2} \]

\[ = \frac{6531}{2} \]

\[ = 3 265,5 \text{ W} \]

**Option 3 / Opsie 3**

\[ R = \frac{V}{I} = \frac{311}{21} = 14,81 \Omega \]

\[ I_{\text{rms}} = \frac{I_{\text{max}}}{\sqrt{2}} \]

\[ = \frac{21}{\sqrt{2}} \]

\[ = 14,85 \text{ A} \]

\[ P_{\text{ave}} = I_{\text{rms}}^2R \]

\[ = (14,85)^2(14,81) \]

\[ = 3 265,83 \text{ W} \]

**Option 4 / Opsie 4**

\[ R = \frac{V}{I} = \frac{311}{21} = 14,81 \Omega \]

\[ V_{\text{rms}} = \frac{V_{\text{max}}}{\sqrt{2}} \]

\[ = \frac{311}{\sqrt{2}} \]

\[ = 219,91 \text{ V} \]

\[ P_{\text{ave}} = \frac{V_{\text{rms}}^2}{R} \]

\[ = \frac{(219,91)^2}{14,81} \]

\[ = 3 265,83 \text{ W} \]

**Question 4**

4.1 The voltage can be altered by using transformers. √ Transformers only operate on AC current. Electrical energy can be transmitted over long distances at low current √, and experience low energy loss.  

(2)

4.2 \[ V_{\text{RMS}} = \frac{V_{\text{max}}}{\sqrt{2}} \]

\[ = \frac{325}{\sqrt{2}} \]

\[ = 0,707 (325) = 230 \text{ V} \]

\[ P_{\text{ave}} = V_{\text{RMS}}I_{\text{RMS}} \]

\[ = 230 \times 13 \]

\[ = 2990 \text{ W} \]
SOLUTIONS TO ELECTROMAGNETIC RADIATION

Question 1 
1.1 (Adapted from Nov 2011, P1, Question 2.10) 
   B  Reason: Gamma rays have highest frequency / energy and shortest wavelength 

1.2 (Adapted from Feb/Mar 2012, P1, Question 2.10) 
   D  Reason: Radiation from the sun includes X-rays which have highest energy and can cause most damage to living things 

1.3 (Adapted from Nov 2011, P1, Question 2.9) 
   D  Reason: The lines on a line emission spectra are formed when electrons move from the excited state to a lower energy level and release the difference in energy as a photon with a particular frequency (colour). 

1.4 (Adapted from Feb/Mar 2012, P1, Question 2.5) 
   C  Reason: For a double slit pattern the bands are evenly spaced as shown 

1.5 (Adapted from Feb/Mar 2012, P1, Question 2.9) 
   C  Reason: Threshold frequency is the minimum frequency required to emit electrons. These photoelectrons have zero kinetic energy. 

Question 2 (Adapted from Nov 2011, P1, Question 7) 
2.1 Light of a single wavelength or single frequency. 

2.2 What is the relationship between the broadness of the central bright band and slit width? 

2.3 Wavelength (of light) / Frequency (of light) / Colour of light / Light source Distance between slit and screen. 

2.4 Increases The angle of diffraction is inversely proportional to slit width. 

2.5 
\[ \sin \theta = \frac{m\lambda}{a} \] 
\[ \sin \theta = \frac{(2)(4 \times 10^{-7})}{2,2 \times 10^{-6}} \] 
\[ \therefore \theta = 21,32^\circ \]
Question 3 *(Adapted from Nov 2011, P1, Question 12)*

3.1 Photoelectric Effect

3.2 Work Function

3.3 \( c = f \lambda \)

\[
3 \times 10^8 = f (330 \times 10^{-9})
\]

\[\therefore f = 9.09 \times 10^{14} \text{ Hz}\]

3.4

\[
\begin{align*}
E &= W_0 + K \\
\frac{hc}{\lambda} &= W_0 + K
\end{align*}
\]

\[\checkmark \text{ Any one}\]

\[
\therefore \frac{(6.63 \times 10^{-34})(3 \times 10^8)}{330 \times 10^{-9}} = 3.5 \times 10^{-19} + K
\]

\[\therefore K = 2.53 \times 10^{-19} \text{ J} \checkmark\]

3.5.1 Remains the same

3.5.2 Increases

3.6.1 Ultraviolet radiation

3.6.2 High Energy / Ionising radiation