NATIONAL SENIOR CERTIFICATE EXAMINATION
EXEMPLAR MARKING GUIDLEINES 2009

PHYSICAL SCIENCES: PAPER I

MARKING GUIDELINES

QUESTION 1

A group of hikers come to a krans (a sheer cliff). The first hiker uses a chain ladder to climb from the soft dry river bed below to the top of the 20 m krans. He takes 1 minute to reach the top.

1.1 State the law of conservation of energy. (2)

The total ✓energy in a closed system remains constant. ✓

1.2 His mass (rucksack included) is 80 kg. Calculate the gain in his potential energy when he reaches the top. (3)

E_p = mgh ✓
= 80.10.20 ✓
= 16 000 J ✓

1.3 Calculate the average power he exerted during his climb to the top. (3)

P = W/ t ✓
= 16000/ 60 ✓
= 270 W ✓

1.4

1.4.1 Calculate the time taken for Orange (A) to reach the river bed below. (3)

S = ut + ½ at^2 ✓
20 = 0 + ½.10.t^2 ✓
T^2 = 20 / 5
T =2 s ✓

1.4.2 **Use energy considerations** to calculate the magnitude of the impact velocity of each of the oranges when it reaches the river bed 20 m below him.

(a) Orange A (4)
(b) Orange B (3)
(c) Orange C (3)

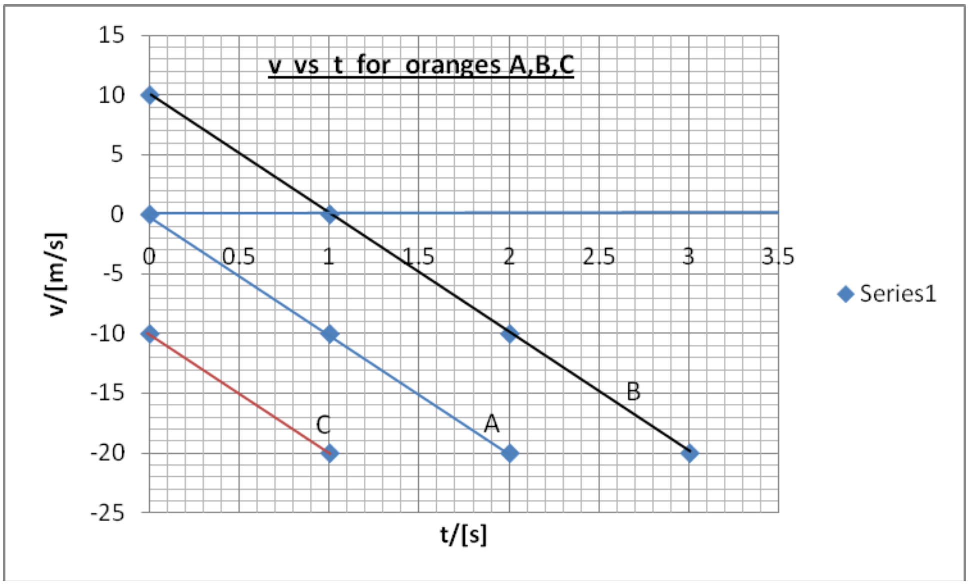
Total energy is conserved, so $E_{initial}$ = E_{final} ✓

For Orange A mgh = E_k = ½mv^2
v^2 = 2.g.h ✓
= 2.10.20 ✓
V = 20 m/s downwards ✓

For Orange B mgh +½mu^2= E_k = ½mv^2
v^2 = 2.g.h + u^2 ✓
= 2.10.20 + 10^2 ✓
V = 22.4 m/s downwards ✓

For Orange C v = v for Orange B ✓✓ (Energy is a scalar)
= 22.4 m/s downwards ✓

1.4.3 Use the graph paper provided on the Answer sheet to draw a velocity vs. time graph on the same set of axes for the flight of each of the three oranges. Label each graph A, B and C to correspond with each of the Oranges A, B and C. (12)



Axes labelled ✓✓
Axes scaled ✓✓
Gradient and label each ✓✓✓
U $_{A,B,C}$ ✓✓✓
Correct v $_{A,B,C}$ ✓✓

No heading – 1

1.4.4 In which way are the flights of the three oranges similar? (1)
They experience the same acceleration ($-10 m/s^2$) ✓

1.4.5 In which way do the flights of the three oranges differ? (1)
They take a different amount of time to reach the riverbed below. ✓

The depth of the crater made by the first orange (A) is 5 cm.

1.5

1.5.1 Calculate the average resultant force experienced by Orange A during impact. (4)

$F_{res}.s$ = ΔE_k ✓ Work Energy theorem
F_{res} = $\Delta E_k/s$
= 20 ✓/ 0.05 ✓
= 400 N upwards ✓

1.5.2 Predict the depth relative to the first crater of the craters made by:
(a) orange B (1)
(b) orange C (1)

Both deeper than for A ✓
B equal to C ✓

1.6 Give advice to the hikers on how to catch an orange which falls from such a height, without causing it to burst. Explain your reasoning. (4)
Reach your hands up towards the orange. ✓ Move your hands down with the orange over as large a distance as possible. ✓✓ Thus exerting as small a force as possible. ✓

1.7 How did the oranges gain potential energy? (1)

Energy was transferred to them by the climber who did work on them. ✓

OR

They experienced an upward force by the climber which displaced them 20 m upwards. ✓

1.8 Describe what happened to the kinetic energy of Orange A? (2)

E_k was transferred to internal energy of riverbed ✓ and the orange itself. ✓

QUESTION 1.9 0R 1.10 (OPTIONAL)

The hiker at the top of the krans throws another orange (D) horizontally at 10 m·s^{-1} away from the krans (over the heads of the hikers).

9.1

1.9.1 Determine the magnitude of its impact velocity with the river bed. (3)

For Orange D v = v for Orange B and C ✓ (Energy is a scalar)
= 22.4 m/s ✓✓ (direction will not be straight down)

1.9.2 Where would it land relative to the other oranges? (4)

Time taken for Orange D to reach the river bed below = 2s =time taken for Orange A ✓

s_x = $v_x t$ ✓ = 10.2 = 20m ✓ further away from the krans. ✓

QUESTION 1.10 (OPTIONAL)

10.1

1.10.1 Write a hypothesis for his question. (2)

Statement ✓ Two variables ✓

1.10.2 Design an experiment to test your hypothesis. (5)

Dependent and Independent variable clearly stated ✓
Measurement of both variables clearly indicated ✓✓
Repeating the fair test and recording ✓
Graphing results and interpreting ✓

55 marks

QUESTION 2 THE DOPPLER EFFECT, LIGHT AND COLOUR

2.1 What is meant by the term 'an emission spectrum'? (3)
electromagnetic radiation ✓ emitted by a self-luminous source, ✓ which is dispersed into its frequencies. ✓

2.2 Explain why each element has its own specific emission spectrum. (4)
Ground state – e^-s in their lowest discrete energy levels. ✓
Stimulation – e^-s absorb energy and move to higher discrete energy levels. ✓
Emission – e^-s return to their lowest discrete energy levels and emit a photon with a specific frequency f corresponding to $\Delta E = hf$. ✓
Each element has unique energy levels. ✓

2.3 Use an example associated with sound waves to illustrate and explain what the Doppler Effect is. (4)
Motor car passing a stationary observer next to the road = neee-oooo, e.g. ✓✓
High f as it approach, lower f as it retreats. (explain ✓✓)

2.4 Explain how the Doppler Effect accounts for the shift in the spectral lines of hydrogen. (4)
The diagram shows the spectral lines shifted towards longer wavelengths (red shift) compared to the discharge tube. ✓✓
I.e. the source is retreating ✓ from the observer. ✓

2.5 Use the diagram above to estimate the magnitude of $\Delta\lambda_1$.
(Show your working clearly) (3)
$\Delta\lambda_1 = 530 - 510 = 20\text{nm}$

2.6 Calculate the corresponding shift in frequency for $\Delta\lambda_1$. (5)
$f_a = c/\lambda = 3 \times 10^8 / 530 \times 10^{-9} = 5{,}7 \times 10^{14}$ Hz ✓✓
$f_b = c/\lambda = 3 \times 10^8 / 510 \times 10^{-9} = 5{,}9 \times 10^{14}$ Hz ✓✓
$\Delta f_1 = 2 \times 10^{13}$ Hz ✓

2.7 Is the speed of the light coming from the star less than, the same as, or greater than the speed of the light coming from the discharge tube? (2)
Equal to c. ✓✓ (special relativity)

2.8 Name a process which may be used to disperse light into a spectrum. (2)
Refraction through a prism or diffraction through a diffraction grating. ✓✓

2.9 Calculate the energy of a photon with a wavelength of 600 nm. (4)
$E = h \cdot c/\lambda$ ✓ $= 6.6 \times 10^{-34} \times 3 \times 10^8 / 600 \times 10^{-9} = 3{,}3 \times 10^{-19}$ J

2.10 Explain what is meant by 'destructive interference'. (3)
Superposition of 2 waves ✓ of same λ, same amplitude, in the same medium ✓ which are out of phase with each other. ✓

2.11 Give two reasons why a photon of ultraviolet light (UV light) is more dangerous than a photon of red light. (4)
E α f, UV has greater f, more E, more dangerous. ✓✓
The λ of UV is of such a length that it interferes with the molecules in our skin, eyes, etc. ✓✓

2.12 Name one other example of dangerous electromagnetic radiation reaching the earth from Space. (1)
Cosmic rays, gamma rays, X rays, IR, Microwaves.

2.13 Do you think that destructive interference can be used to cancel the UV radiation which reaches earth from Space? Use your knowledge of waves to justify your answer. (5)
No ✓
UV rays come from atoms in the sun. ✓
The rays are not all equal in amplitude, λ. ✓✓
Impossible to transmit a wave to 'destroy' every incident wave. ✓
(FOR insufficient energy available to transmit these waves ✓✓)

2.14 Name the three primary subtractive colours. (3)
Cyan, magenta, yellow.

2.15 What is meant by 'complementary colours'? (2)
Colours that combine together ✓ to produce white light. ✓

2.16 Name the complementary colour of red. (1)
Cyan

2.17 Explain how the colour red can be produced using colour subtraction. (6)
Yellow reflects green and red. ✓✓
Magenta reflects red and blue. ✓✓
Red will be reflected. ✓✓ (the rest will be absorbed)

56 marks

QUESTION 3 ELECTROMAGNETISM AND ELECTRIC CURRENT

3.1 Identify two energy transfers that are taking place in order to produce a beam of light. (4)

$E_k \rightarrow E_{electrical}$ ✓✓
$E_{electrical} \rightarrow E_{light}$ ✓✓

3.2 The advertisement refers to Faraday's Law of Induction. State this Law. (3)

The emf induced in a coil ✓ is directly proportional to the rate ✓ of change of magnetic flux ✓ through it.

3.3 Describe three modifications which could be made to this type of torch and/or to its operation so that the amount of energy transferred by each shake of the torch is increased. (3)

Stronger magnet ✓ more coils ✓ shake harder ✓

A kinetic torch costs R 80.00. A conventional torch of similar brightness costs R 25.00, and its two batteries (cells) cost R 7.00 each. The expected life of the cells when the torch is switched on is 8 h.

3.4 Draw up a table showing the advantages and disadvantages of both kinetic torches and conventional torches. (8)

	kinetic torches	**conventional torches**
advantages		
disadvantages		

Table ✓✓
Valid Points – up to 6

3.5 Use your table to write a short paragraph which gives **your opinion** of the value using a kinetic torch compared the value of using a conventional torch. (3)

Clear Choice ✓
Sound reasoning ✓✓

3.6 Explain how magnetic poles are produced on the coil when the magnet is entering the coil. (4)

As the N pole approaches from the top, the flux through the coil increases. ✓
An emf is induced so as to oppose this increase,
A north pole is induced at the top of the coil. ✓

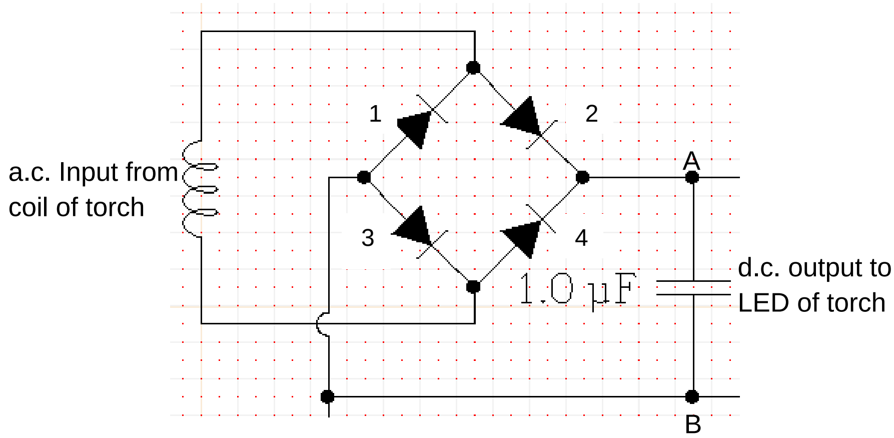
As the S pole exits from the bottom, the flux through the coil decreases. ✓
An emf is induced so as to oppose this decrease,
A north pole is induced at the bottom of the coil. ✓

The time taken for the magnet to fall down the length of the tube is 0,25 s.
The time taken for a similar piece of copper to fall down the length of the tube is 0,19 s.

3.7 Use the principle of conservation of energy to explain why it takes less time for the piece of copper to fall down the tube than for the magnet (of same mass and size) to fall down the tube. (6)

For magnet, $E_p \rightarrow E_{electric}$ and Ek
For non magnetic metal, $E_p \rightarrow E_k$ only
Hence non magnetic metal has greater E_k and greater v, hence takes less time.

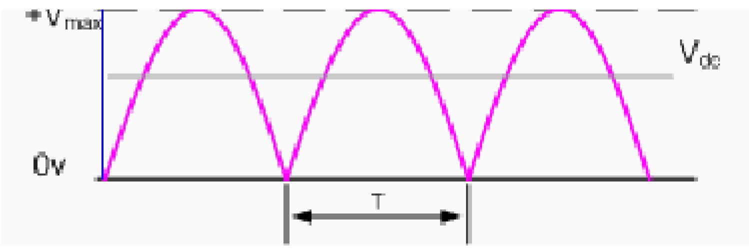
3.8 The alternating current (a.c.) generated in the coil of the kinetic torch is rectified to flow in one direction only using a bridge rectifier shown in the circuit diagram below.



3.8.1 Draw a sketch graph of the a.c. input from the coil of the torch. (2)

3.8.2 What is the function of any one of the diodes in this circuit? (1)
To conduct current in one direction only. ✓

3.8.3 Draw a sketch graph of the d.c. output to the LED of the torch. (2)



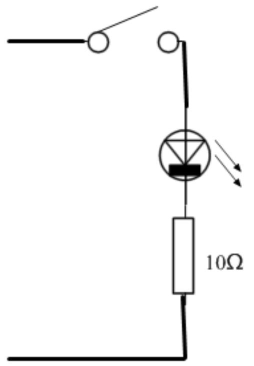
Axes ✓
Shape all positive ✓

3.8.4 Explain briefly how light is emitted from the LED when it is forward biased. (4)
Forward biasing reduces the depletion layer. ✓
Current flows across the p-n junction. ✓
Recombination results in photons being emitted. ✓✓✓

ANSWER EITHER QUESTION 3.9 OR QUESTION 3.10 (OPTIONAL)

3.9 The complete circuit for the kinetic torch includes a LED, a switch and a 10 Ω resistor connected to the d.c. output. The resistor limits the current to the diode.

3.9.1 Starting from connection points A and B respectively draw the remainder of the circuit diagram to show how the LED, switch and resistor are connected to the d.c. output. (4)



In series ✓
Correct symbols ✓

3.9.2 Calculate the amount of charge which passes through the LED in 5 minutes when a steady d.c. current of 10 mA passes through it. (4)
$Q = It = 10 \times 10^{-3}$ ✓ $\times (5 \times 60)$ ✓ $= 3C$ ✓✓

3.9.3 Calculate the amount of electrical energy used by the LED in 5 minutes when a steady potential difference of 1,8 V is applied across it. (4)
$E = VQ$ ✓ $= 1{,}8 \times 3$ ✓ $= 5{,}4$ J ✓✓

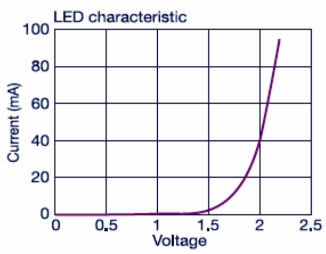
3.9.4 What is the function of the capacitor in this circuit? (2)
To store the charge coming from the rectifier ✓ until it is needed. ✓

3.9.5 Which side of the capacitor (A or B) is positive in this circuit? A ✓ (1)

ANSWER QUESTION 3.10 IF YOU HAVE NOT ANSWERED QUESTION 3.9

QUESTION 3.10 (OPTIONAL)

3.10 The graph shows the characteristic of a LED which is to be used in the circuit for the kinetic torch shown. For optimum life and light efficiency the current through the LED should be 40 mA. At higher currents the LED will be brighter, but its life is shortened and it will burn out rapidly if the current exceeds 90 mA.



3.10.1 Is the LED ohmic or non-ohmic? Explain. (3)
Non- Ohmic ✓ Graph shows ✓ I vs V not straight line thru origin ✓

3.10.2 Determine the resistance of the LED under the best conditions. (4)
$R = V/I$ ✓ $= 2$ ✓$/ 40 \times 10^{-3}$ ✓ $= 200\Omega$ ✓

3.10.3 What is the maximum power that can be consumed by the LED? (4)
$P = V \times I$ √ $= 2{,}1$ ✓ $\times 90 \times 10^{-3}$ ✓ $= 0{,}19$ W ✓

3.10.4 Explain how a resistor connected in series with the LED can limit the power that is consumed by the LED. (4)
R in series increases R_{TOT}, ✓ reduces I, ✓ Reduces $P = I^2 R_{LED}$. ✓✓
OR R in series voltage divider ✓ reduces V_{LED} ✓ Reduces $P = V^2 / R_{LED}$.✓✓

55 marks

QUESTION 4 MATTER AND MATERIALS: USING A PHOTODIODE

4.1 Briefly describe what the photoelectric effect is. (3)
The photoelectric effect is the ejection of electrons from the surface of a material ✓ when light (EM radiation) shines on it. ✓ With a sufficiently high frequency ✓

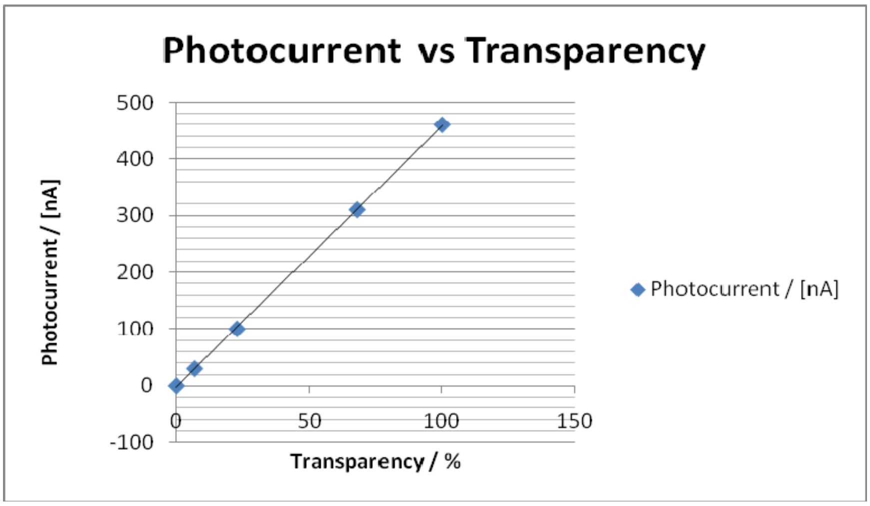
4.2 Explain how why the photodiode does not respond to infra-red photons, regardless of the intensity of the infra red source. (4)
The frequency of the IR radiation ✓ is less than ✓ the threshold frequency ✓ of the material. ✓

OR

$E_{IR\ photon}$ < Work function

4.3 List two variables which must be controlled in this experiment. (2)
The light source ✓ the distance of the light source from the material ✓

4.4 Using the graph paper in the Answer Booklet, plot a graph of these results. (8)



Axes labelled ✓
Heading ✓
Scales ✓
PLOTTING ✓✓✓
Best fit ✓✓

4.5 Describe how the photocurrent is related to the percentage transparency of the different types of materials. (1)
Directly proportional. ✓

4.6 Explain why the photocurrent increases when the percentage transparency increases. (2)

All visible light has sufficient E for the photodiode to emit photoelectrons. ✓
The greater the transparency, ✓ the more photons reach the photodiode, ✓ the more current.

4.7 Explain how this experiment could be adapted to measure the transparency for UV light only and not visible light. (4)

The photodiode could be changed ✓✓ for one with a cut off frequency $> f_{violet}$ ✓✓

OR

A filter only allowing UV ✓ to pass could be placed over ✓ the sample material. ✓✓)

The transparency of some sunglasses is tested. A dark sunglass lens produces a current of 70 nA and a light polariod lens produces a current of 200 nA. Polaroid lenses cut out the glare reflected from smooth surfaces.

4.8 Determine the transparency of each lens:

4.8.1 Dark sunglass lens (2)

4.8.2 Light Polaroid sunglass lens (2)

Marks on graph indicating interpolation. ✓✓
15 % and 45 % ± 3% ✓✓

4.9 Discuss the advantages and disadvantages of each of these types of lenses when worn by the driver of a motor vehicle at sunset. (6)

	Normal lens	**Polaroid lens**
advantages		
disadvantages		

Table ✓✓
Valid Points – up to 4

34 marks