



RWANDA-MINEDUC
TTCs JOINT EXAMINATIONS



TTC COMPREHENSIVE EXAM

MAXIMUM MARKS: 100

LEVEL: YEAR III

Date: 15/03/2023

OPTION: SME

Duration: 3hours

TERM: II

SUBJECT: PHYSICS

INSTRUCTIONS:

- 1) Organize your time so that you can complete all questions.
- 2) Do not answer unnecessary things, answer what is asked.
- 3) Do not open this question paper until you are told to do so.
- 4) Draw a line after each question
- 5) This paper consists of three sections **A, B and C.**

Section A: Attempt **ALL** questions. **(55 marks)**

Section B: Attempt **any three** questions. **(30 marks)**

Section C: Compulsory questions. **(15 marks)**

- 6) Non-programmable scientific calculator and mathematical set may be used.

7) Useful constants

The mass of electron $m_e = 9.11 \times 10^{-31} \text{ kg}$

Planck's constant $h = 6.62 \times 10^{-34} \text{ J.s}$

Speed of light in vacuum $C = 3 \times 10^8 \text{ m/s}$

Electron charge $e = 1.6 \times 10^{-19} \text{ C}$

Acceleration due to gravity $g = 9.81 \frac{\text{m}}{\text{s}^2}$

SECTION A: ATTEMPT ALL QUESTIONS (55 marks)

1) (a) What is meant by the term “planet’s albedo”? **(1 mark)**

(b) Enumerate any two factors that determine the “Earth’s albedo”? **(2 marks)**

2) An optical fiber has refractive index of core 1.50 and of cladding 1.47. Calculate:

a) Critical angle at the core cladding interface. **(2 marks)**

b) Numerical aperture of the fiber. **(2 marks)**

c) Acceptance angle for the optical fiber in air **(1 mark)**

3) Complete the missing terms in the blank spaces of the following statements.

a) A compound microscope consists of two lenses, an..... (Close to the object) and an..... (Close to the eye). **(2 marks)**

b) In the human eye, a real and.....(image is formed on the light sensitive surface called the..... **(2 marks)**

4) Match each of elementary particles **(Column A)** with its description **(Column B)** **(4 marks)**

Column A	Column B
a) Fermions	i) Carry strong nuclear forces between matter particles
b) Quarks	ii) Antiparticle of electron
c) Positron	iii) Have half integer spins

d) Gluons	iv) Make up hadrons such as protons and neutrons
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5) A light falls on two slits 3 cm apart that are at a distance of 1m from the screen. If they produce the sixth order bright line 1mm from the centre of the pattern, what is the wavelength of the light used? **(3 marks)**

6) a) The relation for the Compton effect is $\lambda' - \lambda = (h/m_e c) (1 - \cos\theta)$

Give the expression of the Compton wavelength of an electron.

(1 mark)

b) How does increasing temperature of a blackbody affect the peak wavelength of emitted radiation from a black body?

Explain your answer.

(2 marks)

7) A section of drainage culvert 1.23 m in length and makes a howling noise when the wind blows.

a. Determine the frequencies of the first three harmonics of the culvert if it is open at both ends. Take $v = 343$ m/s as the speed of sound in air. **(2 marks)**

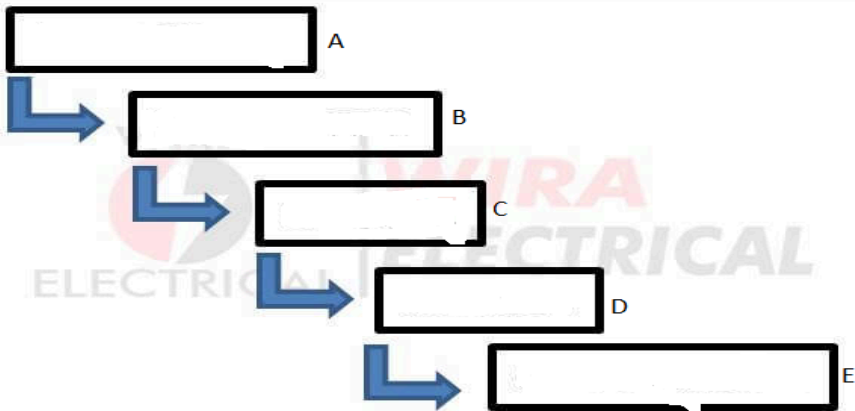
b. What are the three lowest natural frequencies of the culvert if it is blocked at one end? **(2 marks)**

c. For the culvert open at both ends, how many of the harmonics present fall within the normal human hearing range (20 Hz to 17 000 Hz)? **(2 marks)**

8) Complete each of the following sentences by choosing the correct term from the following words: **loudness, pitch, sound quality, echoes, intensity and noise**

- a. The ----- of a sound wave depends on its amplitude **(1 mark)**
- b. Reflected sound waves are called ----- **(1 mark)**
- c. Two different instruments playing the same note sound different because of ----- **(1 mark)**

9) The diagram below is about optical fiber communication system. Fill the spaces A to E by corresponding terms from the list: **transmitter, channel, output signal, input signal** and **receiver**. **(2.5marks)**



10) Classify fundamental interactions from the strongest to the weakest **(2 marks)**

11) Scientists have recently discovered a type of particle called a pentaquark. Pentaquarks are very short lived and contain five quarks. A lambda b (Λ_b) pentaquark contains the following quarks: 2 up, 1 down, 1 charm, and 1 anticharm quark.

The following table contains information about the charge on the quarks that make up the Λ_b pentaquark.

Type of quark	Charge
---------------	--------

Up	$+\frac{2}{3}e$
Down	$-\frac{1}{3}e$
Charm	$+\frac{2}{3}e$
Anticharm	$-\frac{2}{3}e$

Determine the total charge of lambda Λ_b pentaquarkb. **(2 marks)**

b. The mean lifetime of another quark-antiquark pair is 8.0×10^{-21} s in its own frame of reference. During an experiment the quark-antiquark pair is travelling with a velocity of $0.91c$ relative to a stationary observer. Calculate the mean lifetime of this quark-antiquark pair relative to the stationary observer

(2 marks)

12) a) Define an optical fiber

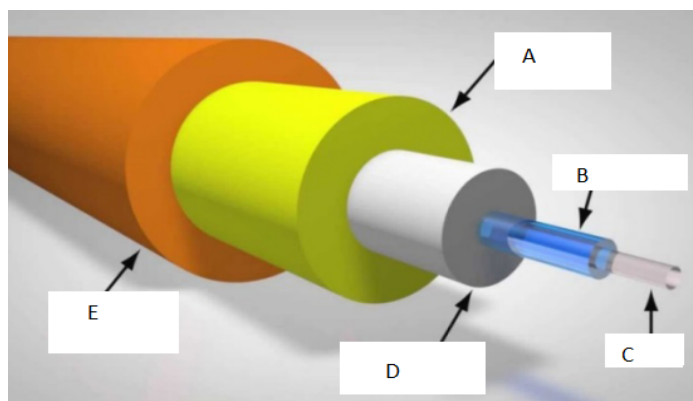
(1 mark)

b) Explain the principle of optical fiber.

(3 marks)

13) Label the diagram below

(2.5marks)



14)a) A boy whistles a sound with the power of $0.5 \times 10^{-4} \text{ W}$. What will be his sound intensity at a distance of 5 m? **(2 marks)**

b) Calculate the intensity level equivalent to an intensity 1 nW/m^2 **(2 marks)**

15)a) Read this advert and answers the question that follows. “Today, Airtel Rwanda has announced the commercial introduction of its long-term Evolution (LTE) services, which are offered over ORN Rwanda’s open access 4G infrastructure, let us migrate from 3G to 4G” What do you think is the benefit of this migration? **(2 marks)**

(b)Write short notes on the following as applied in signal broadcasting.

(1) Amplitude modulation. **(1 mark)**

(2) Frequency modulation. **(1 mark)**

(3) Phase modulation. **(1 mark)**

SECTION B: Attempt any three questions (30 marks)

16) a) How can you connect two dry cells

(i) in series? **(1 mark)**

(ii) in parallel? **(1 mark)**

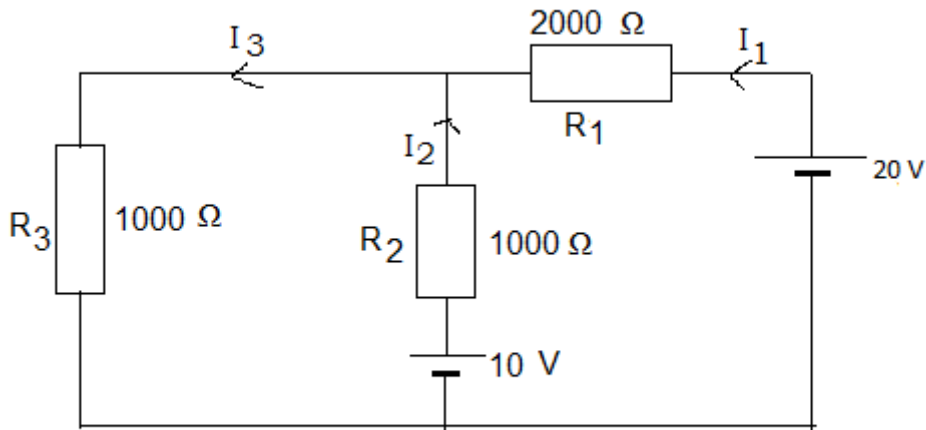
b) Five cells each with an emf of 2V and internal resistance of 0.5Ω are connected in parallel. Find

(i)the emf of the resultant battery **(1 mark)**

(ii)the internal resistance of the resultant battery **(1 mark)**

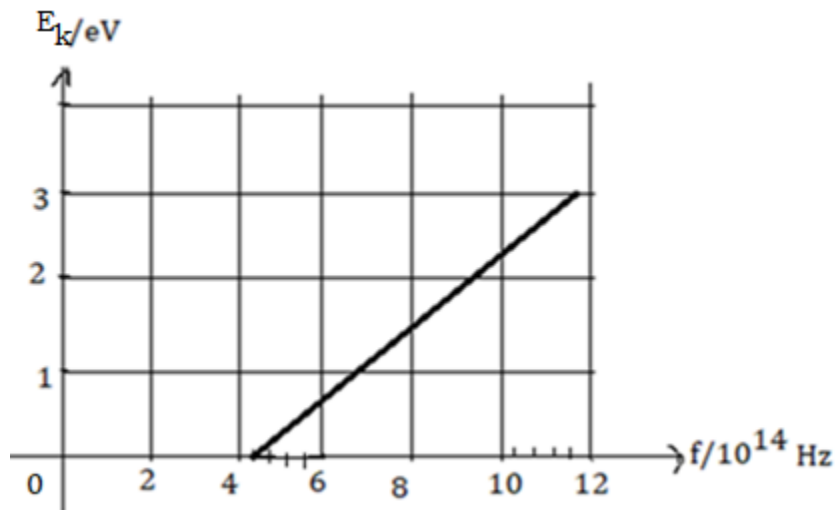
c) Use Kirchhoff’s laws to find the electric currents I_1, I_2, I_3 through

each resistor in the following circuit **(6 marks)**



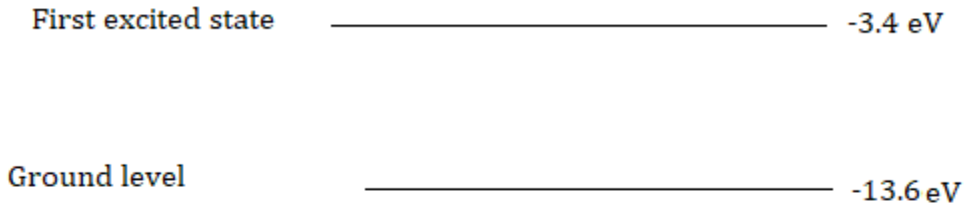
17) a) The graph in the figure below shows how the energy E_k of photoelectrons emitted from the surface of sodium metal varies with frequency f of the incident radiation.

Planck constant $h = 6.62 \times 10^{-34} \text{ m}^2 \text{ kg/s}$



- 1) Find the threshold frequency **(2 marks)**
- 2) Calculate the work function of sodium in J or eV **(2 marks)**

b) The lowest energy of a hydrogen atom are shown below



(i) Determine the energy of level $n=3$ (second excited state) of the

hydrogen atom($E_n = \frac{-13.6eV}{n^2}$) **(2 marks)**

(ii) A free electron with kinetic energy $12eV$ collides with an atom of hydrogen and causes it to be raised to its first excited state ($n=2$).

1) Determine the energy absorbed when electron jumps from ground level $n=1$ to $n=2$ **(3 marks)**

2) Calculate the kinetic energy of the free electron in eV after the collision **(1 mark)**

18) When the mean optical power launched into an 8 km length of fiber is $120 \mu W$, the mean optical power at the fiber output is $3 \mu W$.

Determine:

a. The overall signal attenuation or loss in decibels through the fiber assuming there are no connectors or splices. **(3 marks)**

b. The signal attenuation per kilometre for the fiber. **(2 marks)**

c. The overall signal attenuation for a 10 km optical link using the same fiber with splices at 1 km intervals, each giving an attenuation of 1 dB. **(3 marks)**

d. The numerical input/output power ratio in (c) **(2 marks)**

19) a) What is meant by Doppler Effect? **(2 marks)**

b) As an ambulance travels east down a highway at a speed of 33.5 m/s, its siren emits sound at a frequency of 400 Hz.

What frequency is heard by a person in a car traveling west at 24.6 m/s

1. as the car approaches the ambulance and **(2 marks)**

2. as the car moves away from the ambulance? **(2 marks)**

3. Suppose the car is parked on the side of the highway as the ambulance speeds by. What frequency does the person in the car hear as the ambulance

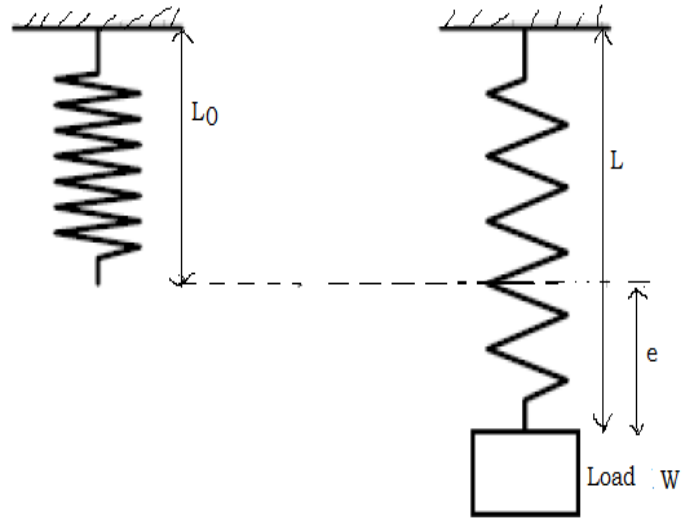
(i) approaches and **(2 marks)**

(ii) recedes? **(2 marks)**

20) Climate change is one of the greatest threats that we face, and it is already having a significant impact on species around the globe. Many scientists have declared this to be the cause to the "sixth extinction of the Earth" Assess the validity of this statement. **(10 marks)**

SECTION C: COMPULSORY QUESTION **(15 marks)**

21) A student carried out an experiment to find the spring constant of a steel spring using Hooke's law . The apparatus is shown below.



The student recorded the unstretched length $L_0=30$ mm of the spring. Then she/he added loads W to the spring, recording the new length L each time. The readings are shown in the table below.

W/N	L/mm	e/mm
0	30	
1	32	
2	33	
3	36	
4	39	
5	40	

Use your knowledge and acquired skills to analyze and answer the following questions.

a) Calculate the extension e of the spring produced by each load, using

the equation $e = L - L_0$. Record the values of e in the table.

(3 marks)

b) Draw the best-fit straight line of load W (along vertical axis) against the extension e (on horizontal axis).

(6 marks)

c) Calculate the gradient K (spring constant) of the graph and interpret the obtained result.

(2 marks)

d) From the graph, state the Hooke's law.

(2 marks)

e) Provide any two real life applications of the Hooke's law.

(2 marks)

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