TONGA FORM SIX CERTIFICATE
2017
PHYSICS

QUESTION AND ANSWER BOOKLET

Time allowed: 3 Hours

INSTRUCTIONS:

1. Write your Student Enrolment Number (SEN) on the top right-hand corner of this page.
2. Additional sheets of paper can be obtained from your supervisor if necessary. Write your Student Enrolment Number (SEN) on each addition sheet. Number the questions clearly and insert them in the appropriate part of your booklet.
3. This paper is divided into FIVE QUESTIONS. ALL of which must be answered.

<table>
<thead>
<tr>
<th>Sections/Topics</th>
<th>Total Skill Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>QUESTION 1: Light and Waves</td>
<td>17</td>
</tr>
<tr>
<td>QUESTION 2: Mechanics</td>
<td>25</td>
</tr>
<tr>
<td>QUESTION 3: Heat Energy and Ideal Gas Laws</td>
<td>7</td>
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<tr>
<td>QUESTION 4: Electricity and Magnetism</td>
<td>13</td>
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<td>QUESTION 5: Electrostatics and Modern Physics</td>
<td>13</td>
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<tr>
<td>TOTAL</td>
<td>75</td>
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</tbody>
</table>

4. Follow the instructions and answer all questions in the spaces provided in this booklet.
5. Check that this booklet contains pages 2-19 in the correct order and that none of the pages is blank.
6. In addition to this Question and Answer Booklet, you should also be issued with a PHYSICS EQUATIONS SHEET (No.1/15).

YOU MUST HAND IN THIS BOOKLET TO THE SUPERVISOR BEFORE YOU LEAVE THE EXAMINATION ROOM.
ATTEMPT ALL QUESTIONS IN THIS EXAM PAPER.

Write the answer to each question in the correct space provided. If you are unable to calculate a value for a question and need that value in a later question, select a convenient value and use where needed.

QUESTION 1: LIGHT AND WAVES

a. A ray of light strikes a mirror at an angle of 40° from the surface of the mirror. State the **angle between the incident and the reflected ray**.

b. Tina, a Form 6 Physics student, wants to investigate the **total internal reflection** by analysing a ray of light in, glass enters the air, at an angle of incident of 49.6°. The refractive index of the glass and air is 1.5 and 1.0 respectively.

i. Define the term **total internal reflection**.

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<th>Skill level 1</th>
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ii. Predict whether or not *total internal reflection* is most likely to occur at the glass-air interface by showing appropriate calculations.

iii. State **ONE** (1) use of *total internal reflection*. 

c. Tina continues to measure different angles of refraction, $Q_2$, by allowing light in air at different incident angle $Q_1$, to enter a pool of water as shown in the diagram below.
The following table shows Tina’s result.

<table>
<thead>
<tr>
<th>$Q_1$</th>
<th>$Q_2$</th>
<th>$\sin Q_1$</th>
<th>$\sin Q_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>36</td>
<td>0.77</td>
<td>0.59</td>
</tr>
<tr>
<td>45</td>
<td>32</td>
<td>0.71</td>
<td>0.53</td>
</tr>
<tr>
<td>40</td>
<td>28</td>
<td>0.64</td>
<td>0.47</td>
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<tr>
<td>35</td>
<td>25</td>
<td>0.57</td>
<td>0.42</td>
</tr>
<tr>
<td>30</td>
<td>21</td>
<td>0.50</td>
<td>0.36</td>
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i. Plot the graph of $\sin Q_1$ against $\sin Q_2$.

ii. Interpret the gradient of the graph in part 1. above.

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<tr>
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<tr>
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<table>
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<tr>
<th>Skill level 1</th>
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<tbody>
<tr>
<td>1</td>
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<tr>
<td>0</td>
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<td>NR</td>
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</tbody>
</table>
d. Interference of light is investigated using a **coherent light source**. Discuss **coherent** as applied to a light source.

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e. Define the term **wavelength**.

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_______________________________________________________________________
_______________________________________________________________________


f. The echo sounder in the MV Maui sends an outgoing sound pulse into the deep ocean as shown in the diagram below.
If the sound pulse takes 1.5 seconds to travel to the seafloor and return back to the ship, determine the **depth** of the ocean. (Use 1500 m.s\(^{-1}\) as the speed of sound in water).

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<td>NR</td>
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</table>
QUESTION 2: MECHANICS

a. Define the term **torque**.

b. In order for a system to be in equilibrium, there are conditions to be met. State ONE (1) of those conditions.

c. A 2 kg ball travelling West at 6 m/s collides with a 3 kg ball travelling South at 4 m/s stick together and move off with a common velocity $v_c$.

i. Apply appropriate formula to determine the magnitude and direction of the common velocity $v_c$. 

Skill level 1

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ii. By doing suitable calculations, predict whether this collision is 
**elastic or inelastic.**

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d. The diagram below shows an object undergoing motion in a circle at constant speed from point A towards point E.

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i. If the time taken for this object to move from point A to E is 0.1 second, state the frequency of the circular motion.
ii. From the sets of vectors below (A, B, C, D), state which set indicate the directions of the **acceleration, \( \mathbf{a} \)**, and the **velocity, \( \mathbf{v} \)**, at point A.

![Diagram of vectors A, B, C, D]

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e. During the intercollegiate athletic competition, Neo’s speed over a small period of time was recorded as follows.

![Graph of speed vs. time]

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i. Between which times interval did Neo completely stop?
ii. In the grid below, create the corresponding acceleration time graph for the whole 20 seconds time of Neo’s motion.

---

f. A projectile is launched with a velocity of 100 m/s at an angle of 30° to the horizontal as shown below.

![Projectile Diagram](image)

Apply appropriate equations to find the Range. (Use $g = 10 \text{ m/s}^2$)
g. A ball dropped from a tower, hit the floor at a velocity of 8 m/s then bounces off with a velocity of 5 m/s. Calculate the change in velocity of the ball.

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h. The diagram below shows a 10 kg cart placed on track at O and is given enough energy to enable it to get over hills P and T and return to a same level track at U. Assume the track from O to U is frictionless.

![Diagram of a cart on a track with hills P and T and level track at U.]

i. Calculate the total kinetic energy of the cart at point R. (Use g = 10 m/s²)

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Skill level 2

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ii. Below is a set of data obtained by Lina, a Form 6 Physics student during an experiment to investigate Hooke’s law.

<table>
<thead>
<tr>
<th>Mass (g)</th>
<th>Weight, $F_w$ (N)</th>
<th>Extension, $x$ (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td></td>
<td>0.02</td>
</tr>
<tr>
<td>300</td>
<td></td>
<td>0.15</td>
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<td>200</td>
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<td>100</td>
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<td>0.05</td>
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<td>0</td>
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<td>0.00</td>
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**Draw** the graph of Force versus extension and **interpret** its gradient.
QUESTION 3:  HEAT ENERGY AND IDEAL GAS LAWS

a. A tank containing 200 L of hydrogen gas at 20 °C is kept under a pressure of 200 kPa. The temperature is raised to 90 °C and the volume decreased to 150 L.

   i. Applying appropriate formula, determine the final pressure of the gas in the container.

   \[
   \text{initial pressure} \times \text{initial volume} = \text{final pressure} \times \text{final volume}
   \]

   \[
   (200 \text{ kPa}) \times (200 \text{ L}) = \text{final pressure} \times (150 \text{ L})
   \]

   \[
   \text{final pressure} = \frac{(200 \text{ kPa}) \times (200 \text{ L})}{150 \text{ L}} = \frac{40000 \text{ kPa \cdot L}}{150 \text{ L}} = \frac{40000}{150} \text{ kPa} = 266.67 \text{ kPa}
   \]

   ii. Define the term pressure.

   Pressure is the force applied per unit area.

b. A 48 W electric heater is switched on for 3.5 seconds and 35 g of ice are found to have melted during this time. Apply appropriate formula to calculate the value for the specific latent heat of fusion for water.

   \[
   \text{heat energy} = \text{mass} \times \text{specific latent heat of fusion}
   \]

   \[
   48 \text{ W} \times 3.5 \text{ s} = 35 \text{ g} \times \text{specific latent heat of fusion}
   \]

   \[
   \text{specific latent heat of fusion} = \frac{48 \text{ W} \times 3.5 \text{ s}}{35 \text{ g}} = \frac{168 \text{ J}}{35 \text{ g}} = 4.857 \text{ J/g}
   \]
QUESTION 4: ELECTRICITY AND MAGNETISM

a. As shown below, is a piece of wire that carries a current of 4.0 A. Draw the magnetic field around the wire.

b. Another piece of wire carries 5.0 A in the direction indicated is placed parallel to the above piece of wire at a distance of 0.40 m as shown below.

i. Draw the magnetic field associated with the two parallel wires.

ii. Calculate the force experienced by each piece of wire of length 0.20 m. Coulomb’s constant, \( k = 9.0 \times 10^9 \text{Nm}^2\text{C}^{-2} \).
c. A piece of conductor is moving with speed $v$ perpendicular to a magnetic field $B$ that is directed into the page as shown.

i. Draw an arrow in the piece of conductor to show the **direction of the current**.

ii. State **Lenz’s law**.

D. An electric jug’s element uses 280 kJ of energy to boil water when connected to 240 V mains. It takes 240 seconds to boil water in the jug. Calculate the **resistance** of the heating element.
e. Evaluate how the design of a transformer influences induction in the secondary coil.
In your discussion, you must include these features;

i. Input connection
ii. Output connection
iii. Winding
iv. Core

<table>
<thead>
<tr>
<th>Skill level 4</th>
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<tbody>
<tr>
<td>4</td>
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<tr>
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<tr>
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<td>0</td>
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<tr>
<td>NR</td>
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</table>
QUESTION 5: ELECTROSTATICS AND MODERN PHYSICS

a. Two charges $Q_1$ and $Q_2$ each experience a force $F$ when separated by a distance $R$ as shown in the diagram below.

If the separation is decreased to $R/3$, determine the new value of the force in term of $F$.

b. Draw the shape and direction of the electric field between the two parallel charged plates shown below.
c. Two point charges $+4 \times 10^{-8}$ C and $-6 \times 10^{-8}$ C are placed 0.20 m apart as shown in the diagram below.

Apply appropriate formula to determine the \textbf{net electric field strength} at point P. Coulomb’s constant, $k = 9.0 \times 10^9$ N m$^2$ C$^{-2}$.


d. A 100 g sample of a particular radioactive isotope was left in a cupboard for 24 days.

After 24 days, the remaining amount was 12.5 g. Calculate the \textbf{half-life} of the isotope.

e. Determine the \textbf{name of particle} $X$ emitted during the following radioactive decay.

f. Three atom X, Y and Z with their mass number and atomic number are given below.

\[
\begin{array}{ccc}
25 & 25 & 26 \\
12 & 13 & 12 \\
\end{array}
\]

By showing the \textbf{number of neutrons of each atom}, explain which two are isotopes.