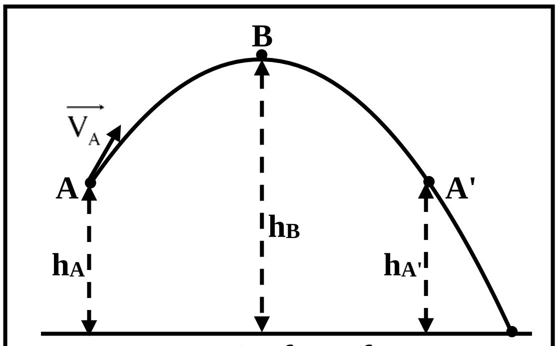
مسابقة في الثقافة العلمية: مادة الفيزياء	الاسم:
المدة: ساعة واحدة	الرقم:

This exam is formed of three exercises in two pages.
The use of non-programmable calculator is recommended.

Exercise 1 (7 points)

Diver's jump

A diver, considered as a particle of mass m = 80 kg, jumps into the water of a swimming pool from the board at point A situated at a height $h_A = 6$ m above the surface of the water. The diver leaves the board with a speed $V_A = 5$ m/s , passes through point A' of height $h_{A'} = h_A$ and reaches the surface of water at point D (Doc. 1).



Doc. 1

Take:

- the surface of water as a reference level for gravitational potential energy;
- $g = 10$ m/s^2.

1) Calculate at point A:
   - **1-1)** the kinetic energy KE_A of the diver;
   - **1-2)** the gravitational potential energy GPE_A of the system (diver, Earth);
   - **1-3)** the mechanical energy ME_A of the system (diver, Earth).

2) The diver attains point B, situated at a height $h_B = 7$ m, with a kinetic energy $KE_B = 200$ J.
   - **2-1)** Determine the mechanical energy ME_B of the system (diver, Earth) at point B.
   - **2-2)** Deduce that air resistance is negligible.

3) Choose with justification the correct answer.
   - **3-1)** During the motion between B and D, the kinetic energy of the diver:
     a) increases **b)** decreases **c)** remains the same
   - **3-2)** The gravitational potential energy of the system (diver, Earth) at A (GPE_A) and that at A' ($GPE_{A'}$) are such that:
     a) $GPE_A < GPE_{A'}$ **b)** $GPE_A = GPE_{A'}$ **c)** $GPE_A > GPE_{A'}$
   - **3-3)** The speed of the diver at point A (V_A) and that at point A' ($V_{A'}$) are such that:
     a) $V_A < V_{A'}$ **b)** $V_A = V_{A'}$ **c)** $V_A > V_{A'}$
   - **3-4)** The work (W) done by the weight of the diver between A' and D is:
     a) W = 1000 J **b)** W = 4800 J **c)** W = 5600 J

Exercise 2 (7 points)

Efficiency of a nuclear power plant

A nuclear power plant uses uranium $^{235}_{92}U$ to produce electric energy.

The aim of this exercise is to determine the efficiency of this nuclear power plant.

One of the possible nuclear reactions of the uranium $^{235}_{92}U$ is given by the following equation:

$$^{1}_{0}n + ^{235}_{92}U \rightarrow ^{94}_{38}Sr + ^{139}_{Z}Xe + x\,^{1}_{0}n$$

Take: m ($^{1}_{0}n$) = 1.0087 u; $c = 3\times10^8$ m/s ; 1 u = 1.66×10^{-27} kg.

Nucleus	$^{235}_{92}U$	$^{94}_{38}Sr$	$^{139}_{Z}Xe$
Mass in u	234.9942	93.8945	138.8892

1) The above nuclear reaction is fission. Justify.

2) Indicate the approximate value of the kinetic energy of a neutron that produces a nuclear fission.

3) Determine z and x, indicating the laws used.
4) Calculate, in u and then in kg, the loss of mass Δm that occurs in this reaction.
5) Calculate, in J, the energy liberated by the fission of one nucleus of uranium ${}^{235}_{92}U$.
6) The nuclear power plant consumes 1 kg of uranium ${}^{235}_{92}U$ in one day.

Assume that all the nuclei of uranium ${}^{235}_{92}U$ undergo fission according to the above equation.

6-1) Show that the energy liberated by the fission of 1 kg of uranium ${}^{235}_{92}U$ is $E = 7.3955 \times 10^{13}$J.
6-2) Deduce the energy E_1 liberated by the fission of the uranium ${}^{235}_{92}U$ in one second.
6-3) The efficiency of this power plant is given by:

$r = \frac{E_{electric}}{E_1}$ where $E_{electric}$ is the electric energy produced in one second.

Calculate the efficiency of this power plant knowing that $E_{electric} = 2.575\times10^{8}$ J.

<u>Exercise 3</u> (6 points)

The history of astronomy

Read carefully the text of document 2 and then answer the questions that follow.

> The ancients believed that the Earth is flat and it is at the center of the universe. The Sun, stars and the other planets rotate around the Earth.
> In the 16th century, the Polish astronomer Nicolas Copernicus claimed that the Earth and the other planets revolve around the Sun and rotate around their axis.
> In 1609, when Galileo Galilei made the first astronomical telescope, he was the first who discovered four satellites of Jupiter (Galilean satellites).
> Until 1609, astronomers thought that the orbits of the planets were circles.
> Johannes Kepler published three laws bearing his name: the first two in 1609 and the third in 1619.
> Few years later, in 1687, Isaac Newton established the law of universal gravitation.
>
> According to the site "*solar system*"
>
> **Doc. 2**

1) The text of document 2 refers to two theories of astronomy.
1-1) Name these two theories.
1-2) Pick up, from document 2, a sentence that related to each theory.
1-3) Indicate one similarity between these two theories.

2) Pick up from document 2 the major contribution in astronomy of:
2-1) Galileo Galilei;
2-2) Isaac Newton.

3) Document 3 shows expressions corresponding to Copernicus' theory and/or to Kepler's laws. Using document 3 copy and complete the table below:

Expression 1	the planets revolve around the Sun
Expression 2	the motion of a planet around the Sun is uniform
Expression 3	The period of revolution of a planet increases with its distance from the Sun
Expression 4	the trajectory of a planet around the Sun is elliptic
Expression 5	the speed of a planet varies with its distance from the Sun
Expression 6	the trajectory of a planet around the Sun is circular

Doc. 3

Two expressions refer to Copernicus' theory	Two common expressions refer to Copernicus' theory and Kepler's laws	Two expressions refer to Kepler's laws
• •	• •	• •

Exercise 1: (7 points) Diver's jump

Part		Answer	Mark
1	1.1	$KE_A = ½\ mV_A^2 = ½\ (80)(5)^2 = 1000$ J	1
	1.2	$GPE_A = mgh_A = 80×10×6 = 4800$ J	1
	1.3	$ME_A = KE_A + GPE_A = 1000 + 4800 = 5800$ J	0.75
2	2.1	$ME_B = KE_B + GPE_B = 200 + mgh_B = 200 + 80×10×7 = 5800$ J	0.75
	2.2	$ME_A = ME_B = 5800$ J The mechanical energy is conserved between A and B, thus the air resistance is negligible.	0.5
3	3.1	**a)** During the motion between B and D, the kinetic energy of the diver increases since its speed increases since: $ME_B = ME_D$; $KE_B + GPE_B = KE_D + GPE_D$; $KE_B + GPE_B = KE_D + 0$ and $GPE_B > 0$ then $KE_D > KE_B$ **<u>OR</u>** : between B and D, GPE decreases and since $ME_B = ME_D$ then KE increases **<u>OR</u>** : KE increases since between B and D the speed of the diver increases.	0.75
	3.2	**b)** The gravitational potential energy of the system (diver, Earth) at A and that at A' are equal since $h_A= h_{A'}$.	0.75
	3.3	**b)** The speed of the diver at point A and that at point A' are equal. Since $ME_A = ME_{A'}$; $KE_A + GPE_A = KE_{A'} + GPE_{A'}$ but $GPE_A = GPE_{A'}$ then $KE_A = KE_{A'}$ then $V_A = V_{A'}$.	0.75
	3.4	**b)** The work done by the weight of the diver between points A' and D is $W = mgh_{A'} = 80×10×6 = 4800$ J.	0.75

Exercise 2: (7 points) Efficiency of a nuclear power plant

Part		Answer	Mark
1		This reaction is fission. The heavy nucleus of uranium is divided into lighter nuclei (Sr et Xe) under the impact of a neutron ($^{1}_{0}n$)	1
2		The kinetic energy of the neutron is around 0.02 eV.	0.5
3		$^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{94}_{38}Sr + {}^{139}_{z}Xe + x\,^{1}_{0}n$ Conservation of mass number A : 1 + 235 = 94 + 139 + x then x = 3 Conservation of charge number Z : 92 = 38 + z then z = 54	1
4		The mass lost $\Delta m = m_{before} – m_{after}$ $\Delta m = (234.9942 + 1.0087) – (93.8945 + 138.8892 + 3×1.0087) = 0.1931$ u Δm in kg $= 0.1931×1.66×10^{-27} = 3.20546×10^{-28}$ kg	1.5
5		$E_{lib} = \Delta m×c^2 = 3.20546×10^{-28} × (3×10^8)^2 = 2.884914×10^{-11}$ J	1
6	6.1	$234.9942×1.66×10^{-27}$ kg $\rightarrow 2.884914×10^{-11}$ J 1 kg $\rightarrow$ E Then : $E = \frac{2.884914×10^{-11}}{3.9009×10^{-25}} = 7.3955×10^{13}$ J	0.75
	6.2	The liberated energy per 1 s : $E_1 = \frac{7.39550×10^{13}}{24\ ×3600} = 8.5596×10^8$ J	0.75
7		efficiency $r = \frac{2.575×10^8}{8.5596×10^8} = 0.30 = 30$ %	0.5

Exercise 3: (6 points) **The History of Astronomy**

<table>
<tr><th colspan="2">Part</th><th colspan="3">Answer</th><th>Mark</th></tr>
<tr><td rowspan="3">1</td><td>1.1</td><td colspan="3">Geocentric theory
Heliocentric theory</td><td>1.5</td></tr>
<tr><td>1.2</td><td colspan="3">Geocentric theory: The ancients believed that the Earth is flat and it is at the center of the universe
<u>OR:</u> The Sun, stars and the other planets rotate around the Earth.
Heliocentric theory: the Earth and the other planets revolve around the Sun.</td><td>1</td></tr>
<tr><td>1.3</td><td colspan="3">One of the following similarities:
• The moon rotates around the Earth.
• The motion of planets is uniform.
• The orbits of planets are circular.
• The universe is spherical.
• Fixed stars carried by a sphere.</td><td>0.5</td></tr>
<tr><td rowspan="2">2</td><td>2.1</td><td colspan="3">Galileo Galilee made the first astronomical telescope.</td><td>0.75</td></tr>
<tr><td>2.2</td><td colspan="3">Isaac Newton established the law of universal gravitation</td><td>0.75</td></tr>
<tr><td colspan="2" rowspan="2">3</td><td>Two expressions refer to Copernicus' theory</td><td>Two common expressions refer to Copernicus' theory and Kepler's laws</td><td>Two expressions refer to Kepler's laws</td><td rowspan="2">1.5</td></tr>
<tr><td>Expression 2
Expression 6</td><td>Expression 1
Expression 3</td><td>Expression 4
Expression 5</td></tr>
</table>