



**Harvard Undergraduate Science Olympiad Dubai
2026 Final Round
7th-8th Grade
Physics Section: Exam**

NAME: _____

Student ID: _____

Score: ____/160

Important Constant Values

Name	Symbol	Value	Units
Gravitational Accel. On Earth	g	9.81	m/s^2
Universal Gravity Constant	G	6.674×10^{-11}	$\frac{m^3}{kg s^2}$
Speed of Light	c	2.998×10^8	$\frac{m}{s}$
Mass of Proton	m_p	1.673×10^{-27}	kg
Mass of Neutron	m_n	1.675×10^{-27}	kg
Mass of Electron	m_e	9.109×10^{-31}	kg
Universal Gas Constant	R	8.315	$\frac{J}{mol K}$
Permittivity of Free Space	ϵ_0	8.854×10^{-12}	$\frac{A^2 s^4}{m^3 kg}$
Permeability of Free Space	μ_0	$4\pi \times 10^{-7}$	$\frac{m kg}{A^2 s^2}$
Avogadro's Number	N_A	6.022×10^{23}	$\frac{1}{mol}$
Elementary Charge	e	1.602×10^{-19}	C
Speed of Sound in Dry Air (STP)	v_s	343	$\frac{m}{s}$

Important Formulas

$v_f = v_i + at$	$x_f = x_i + v_i t + \frac{at^2}{2}$	$v_f^2 = v_i^2 + 2a(x_f - x_i)$
$F = ma$	$a = \frac{v^2}{r}$	$p = mv$
$F_f = \mu N$	$F_k = -kx$	$W = Fd$
$KE = \frac{mv^2}{2}$	$U_g = mgh$	$U_k = \frac{kx^2}{2}$

$I_d = I_0 + md^2$	$L = I\omega$	$\tau = I\alpha$
$I_{ring} = mr^2$	$I_{disk} = \frac{mr^2}{2}$	$I_{stick, center} = \frac{ml^2}{12}$
$f = \frac{\omega}{2\pi} = \frac{1}{T}$	$T = 2\pi\sqrt{\frac{L}{g}}$	$T = 2\pi\sqrt{\frac{m}{k}}$
$F_E = \frac{q_1q_2}{4\pi\epsilon_0r^2}$	$F = qE$	$V = -Ed$
$F_G = \frac{Gm_1m_2}{r^2}$	$R_{eq, series} = \Sigma R$	$\frac{1}{R_{eq, parallel}} = \Sigma \frac{1}{R}$
$V = IR$	$I = \frac{q}{t}$	$E = hf$
$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o}$	$f = \frac{r}{2}$	$v = \lambda f$

INSTRUCTIONS:

The HUSO Dubai Final Round Physics section consists of 10 problems. Each problem will contain several subsections, with point values provided in parentheses. Raise your hand if you think you found a mistake or if you have questions. Also, raise your hand if you are missing some of the 12 pages from this exam. You may spend 1 hrs on the Physics section and may not work on any other section during this time.

All answers must be written in the designated answer sheets. Any writing on the exam booklet outside the answer sheets will not be graded. You may write in this booklet, but **NO WRITING IN THIS BOOKLET WILL BE GRADED**. Feel free to use this booklet as extra scratch paper. Partial credit will not be given for an incorrect answer. However, incorrect answers will not lead to negative points.

The Physics section will contain several short answer questions. Each short answer question will have several subsections, each of which will only require a numerical answer, algebraic expression, or a few words. All algebraic answers can be written in terms of given variables and universal constants. If you make a mistake in an earlier part of a question and a later part of the question requires your earlier answer, full credit will be given if your calculations in the later part are correct but your answer is wrong because you use the wrong value from the last part.

You must bring a #2 pencil or pen, and an eraser. You are allowed to bring a non-programmable, non-graphing calculator and a wrist-watch. You are not allowed to bring a smart watch, textbooks, notes, or any other electronic devices.

Best of luck!

1. From First Principles

- a. Write down Newton's First Law. (2)

- b. Write down Ohm's Law. (2)

- c. Which standard phase of matter has the least kinetic energy per unit atom? (2)

- d. Write down Newton's Law of Gravitation. (2)

- e. The specific heat of water is $4.184 \frac{J}{g^{\circ}C}$. What is that value in using units of $\frac{cal}{g^{\circ}C}$? (2)

2. Hard as Steel

- a. The density of steel is 7850 kg/m^3 . Suppose we have a block of steel with base dimensions of 4 meters by 3 meters. If the mass of the block is 471000 kg, how tall is the block? (2)

- b. Suppose we doubled the width, length, and height of the block. What is the mass of the new steel block in kilograms? (3)

- c. Let's say that we have a small steel block sliding down a plane with an angle of 30° . If this is a frictionless plane, what is the acceleration of the block? (4)

- d. Now suppose that the coefficient of friction between the steel block and plane is exactly $\mu = \frac{1}{\sqrt{3}}$. What is the new acceleration of the steel block? (5)
- e. We now create a steel spring that has a spring constant of 80,000 N/m. How much force is necessary to stretch the spring 1 cm past its equilibrium length? (3)
- f. Finally, we can take two steel balls of equal mass and throw them towards each other with equal velocity. If we assume that the magnitude of momentum is equal to p for both balls right before the collision, what is the change in momentum for each ball if the collision is elastic? (5)

3. House of Mirrors

Throughout this whole problem, assume that you keep your head level (you only turn your head left or right, not up or down).

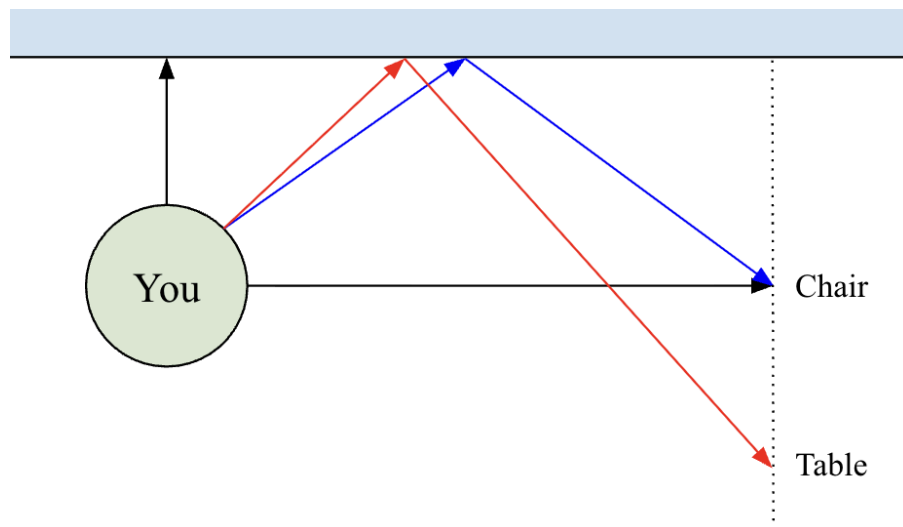


Fig. 1: Objects in a mirror

- a. You walk into a room that features a large, flat mirror on one wall. You look immediately forward and see yourself in the mirror. You look to the right, and see that you are in line with a chair. You are 2 meters away from the mirror. If you look towards the mirror, 60° to the right, you can see the chair in the mirror. How far are you from the chair? (4)
- b. You also notice a table that is aligned with the chair (if there was a line connecting the table and chair, it would be perpendicular to the mirror). If you need to look 45° to the right to see the table, how far is the table away from the mirror? (4)
- c. How far is the table away from the chair? (3)
- d. How far is the table away from you? (5)

4. Fun With Circuits

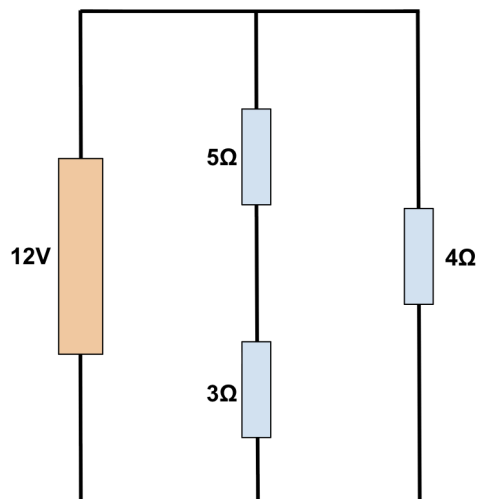


Fig. 2: A Simple Circuit

- a. What is the name of the unit being represented by the symbol Ω ? (2)

- b. What is the total resistance of the middle branch of the circuit? (2)

- c. What is the total resistance of the entire circuit? (3)

- d. What is the current through the middle branch of the circuit? (3)

- e. How much power is dissipated as heat for this entire circuit? (5)

5. Space Mission

You are the captain of a spaceship traveling through space to discover new parts of the universe. Your space agency has plotted different planets using x, y, and z coordinates with the origin located at the Sun. The coordinates are in units of light-minutes, which is how far light can travel in one minute.

Location	(x, y, z) coordinates
Sun	(0, 0, 0)
Earth	(2, 8, 0)
Jupiter	(38, 20, 0)
Pluto	(163, 281, 21)

Table 1: Coordinates of the Planets

- a. In light-minutes, what is the distance between Earth and Jupiter at this point in time? (4)

- b. The ecliptic plane is the name for the plane in which most of the planets orbit the sun. Suppose there was a line connecting the Sun and Pluto. What would the angle be between this line and the ecliptic plane in degrees? (6)

- c. Your navigator proposes a path that will supposedly take you from the Earth to Jupiter in under a minute. Why is this not possible? (6)

6. A Matching Game about Matches

Below, there will be two lists: one list of ___ events, and one list of ___ physical laws/phenomena. For each event, identify the best physical law that is responsible for it. (2.5 each)

- a. A goalie is pushed backwards when stopping a ball
 - b. A lit match is able to heat up a plate of food half a meter away
 - c. A spinning ball continues to spin as it flies through the air
 - d. A matchbox appears “broken” when viewed through a glass of water
 - e. A piece of fish is cooked by a hot pan on the stove
 - f. A dropped ball speeds up as it falls
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1. Snell’s Law
 2. Conductive heating
 3. Convective heating
 4. Conservation of energy
 5. Conservation of momentum
 6. Conservation of angular momentum

7. The Great Block of Ice

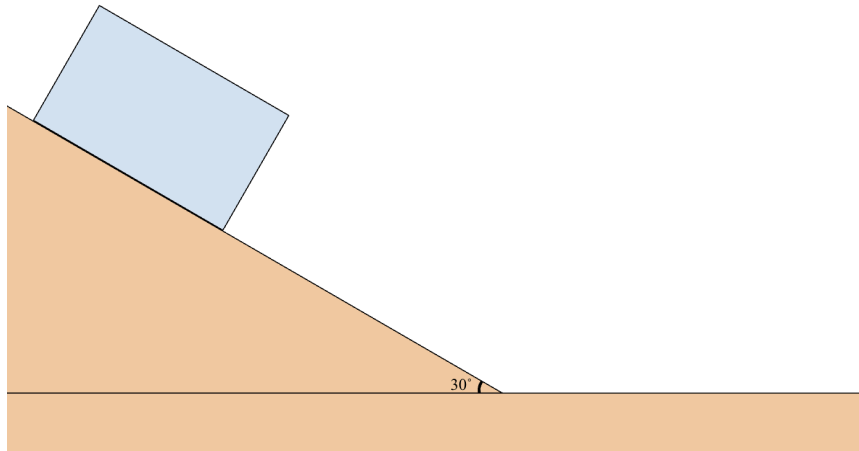


Fig. 3: A Block of Ice on a Hill

- a. A very large block of ice is sliding down a hill angled at 30° . Using the fact that the density of ice is about 900 kg/m^3 , what is the mass of the block of ice in kg if it has a width of 15 meters, a length of 20 meters, and a height of 10 meters? (2)

- b. Assuming that there is no friction between the ice and the hill, what is the acceleration of the ice? (3)

- c. Now, the ice is travelling on flat ground with an initial speed of 83.3 m/s . If there is a coefficient of friction between the ice and flat ground of 0.25, what will the speed of the ice be after 12 seconds? (5)

- d. How many seconds will it take in total for the block to come to a complete stop? (4)

8. Flight of the Bumblebee

- a. A bumblebee is flying in a perfect circle with a radius of 2 meters, and a speed of 15 m/s. How many seconds will it take for the bee to complete one lap? (3)

- b. In radians per second, what is the angular velocity of the bee? (3)

- c. Assuming that the speed of the bee is constant, what is the bee's radial acceleration? (3)

- d. Assuming that the speed of the bee is constant, what is the bee's tangential acceleration? (3)

- e. If the mass of the bee is 1×10^{-4} kg, what is the force needed to ensure that the bee can fly at this speed? (5)

9. Look at this Graph

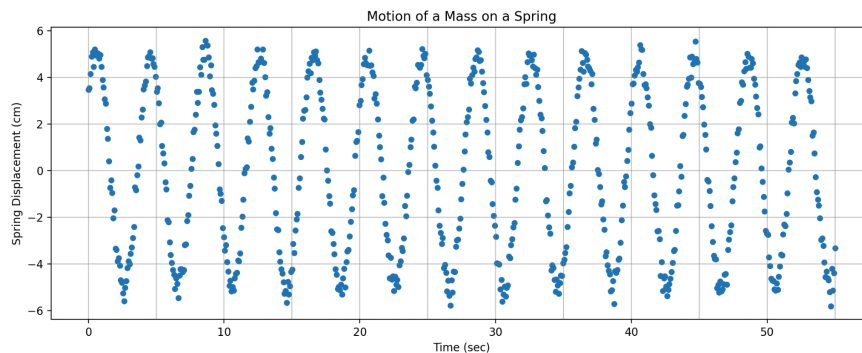


Fig. 4: Graph for part a.

- a. Oscillation data is plotted in the above graph. Find the period and amplitude. (4)

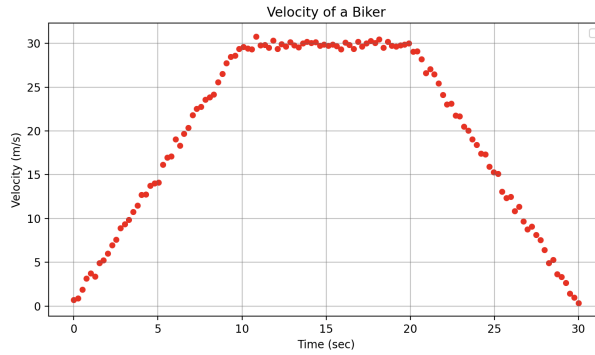


Fig. 5: Graph for parts b. and c. All motion is along x direction.

- b. For each individual time frame, determine what the bike's acceleration is. (3 each)
- i. $0 < t < 10$
 - ii. $10 < t < 20$
 - iii. $20 < t < 30$
- c. What is the total displacement of the bike from the period of 0 to 30 seconds? (4)

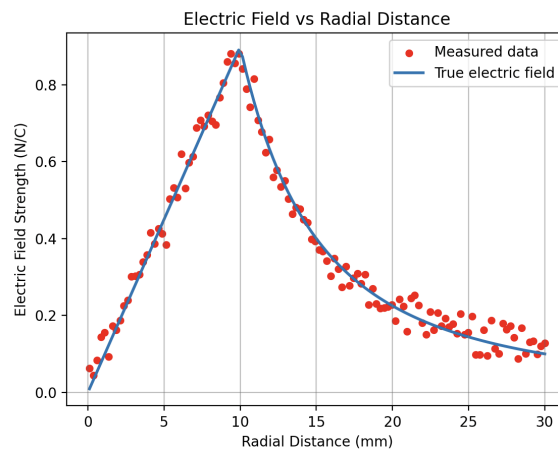


Fig. 6: Graph for parts d.

- d. The above graph shows the electric field as a function of radial distance away from the center of a charge distribution. Qualitatively describe what the charge distribution looks like. (6)

10. Taking a Rocketship to Space

- a. Assume that the mass of a planet is M and the mass of a rocket on the surface of the planet is m . If the planet has a radius of R , what is the expression for the gravitational potential energy between the planet and the rocket? (4)

- b. Suppose instead of a typical rocket launch, all of the rocket's fuel gets expelled in one shot. Come up with an expression for the velocity that the rocket would need to be launched at to escape from the Earth's gravity. (5)

- c. The Earth has a density of $5.5 \times 10^3 \text{ kg/m}^3$, and a radius of 6.371×10^6 meters. What is the escape velocity on the surface of Earth? (3)