State of Israel
Ministry of Education
Type of exam:
א. *Bagrut* for high schools
ב. *Bagrut* for external students
Exam date: Summer 2016
Exam number: 036002, 655
Attachment: Data and formulas for 5-point Physics
English translation (3)

Physics
Electricity

For 5 points

Instructions for examinees

א. Duration of the exam: 105 minutes

ב. Exam structure and breakdown of points:
This exam has five questions. Answer only three of these questions. Each question – $33\frac{1}{3}$ points;
$3 \times 33\frac{1}{3} = 100$ points

ג. Material that may be used during the exam:
(1) A calculator.
(2) The formulas and physics data attached to this exam.
(3) A Hebrew-foreign language/foreign language-Hebrew dictionary.

ד. Special instructions:
(1) Answer the number of questions that you are asked to answer. Answers to additional questions will not be graded. (The answers will be graded in the order that they appear in the test booklet.)
(2) In the solutions to questions that require calculations, write out the formulas that you use. Whenever you use a symbol that does not appear on the formula sheet, write out the meaning of that symbol in words. Before you perform your calculations, insert the appropriate values into the formulas. In your answers, write the appropriate units. If you do not write out the formula, or if you do not write out the formula with the inserted values, or if you do not write the units, points may be deducted from your score.
(3) When you are asked to express a value using data provided in the question, write out a mathematical expression that includes all or some of the given data. When necessary, you may also use basic constants, such as the free-falling acceleration g or the elementary charge e.
(4) In your calculations, use the value 10 m/s^2 for free-falling acceleration.
(5) Write your answers in pen. Writing in pencil or erasing with White-Out will prohibit any possibility of appealing your score. You may use a pencil for drawings only.

Write in the answer booklet only, on separate pages, everything that you want to write as a draft (notes, calculations, etc.) Write the word "טיוטה" on the top of each draft page. Writing any sort of drafts on pages outside of the exam booklet may lead to the disqualification of the exam!

Good Luck!

מדינת ישראל
משרד החינוך
סוג הבחינה:
א. בגרות לבתי ספר על־יסודיים
ב. בגרות לנבחנים אקסטרניים
מועד הבחינה: קיץ תשע"ו, 2016
מספר השאלון: 036002, 655
נספח: נתונים ונוסחאות בפיזיקה ל–5 יח"ל
תרגום לאנגלית (3)

פיזיקה
חשמל

לתלמידי 5 יחידות לימוד

הוראות לנבחן

א. משך הבחינה: שעה ושלושה רבעים (105 דקות).

ב. מבנה השאלון ומפתח ההערכה:
בשאלון זה חמש שאלות, ומהן עליך לענות על שלוש שאלות בלבד.
לכל שאלה — $33\frac{1}{3}$ נקודות; $3 \times 33\frac{1}{3} = 100$ נקודות

ג. חומר עזר מותר בשימוש:
(1) מחשבון.
(2) נספח נוסחאות ונתונים בפיזיקה המצורף לשאלון.
(3) מילון עברי-לועזי / לועזי-עברי.

ד. הוראות מיוחדות:
(1) ענה על מספר שאלות כפי שהתבקשת. תשובות לשאלות נוספות לא ייבדקו. (התשובות ייבדקו לפי סדר הופעתן במחברת הבחינה.)
(2) בפתרון שאלות שנדרש בהן חישוב, רשום את הנוסחאות שאתה משתמש בהן.
כאשר אתה משתמש בסימן שאינו בדפי הנוסחאות, כתוב במילים את פירוש הסימן. לפני שאתה מבצע פעולות חישוב, הצב את הערכים המתאימים בנוסחאות. רשום את התוצאה שקיבלת ביחידות המתאימות. אי־רישום הנוסחה או אי־ביצוע ההצבה או אי־רישום היחידות עלולים להפחית נקודות מהציון.
(3) כאשר אתה נדרש להביע גודל באמצעות נתוני השאלה, רשום ביטוי מתמטי הכולל את נתוני השאלה או חלקם; במידת הצורך אפשר להשתמש גם בקבועים בסיסיים, כגון תאוצת הנפילה החופשית g או המטען היסודי e.
(4) בחישוביך השתמש בערך 10 m/s^2 לתאוצת הנפילה חופשית.
(5) כתוב את תשובותיך בעט. כתיבה בעיפרון או מחיקה בטיפקס לא יאפשרו ערעור. מותר להשתמש בעיפרון לסרטוטים בלבד.

כתוב במחברת הבחינה בלבד, בעמודים נפרדים, כל מה שברצונך לכתוב בטיוטה (ראשי פרקים, חישובים וכדומה). רשום "טיוטה" בראש כל עמוד טיוטה. רישום טיוטות כלשהן על דפים שמחוץ למחברת הבחינה עלול לגרום לפסילת הבחינה!

בהצלחה!

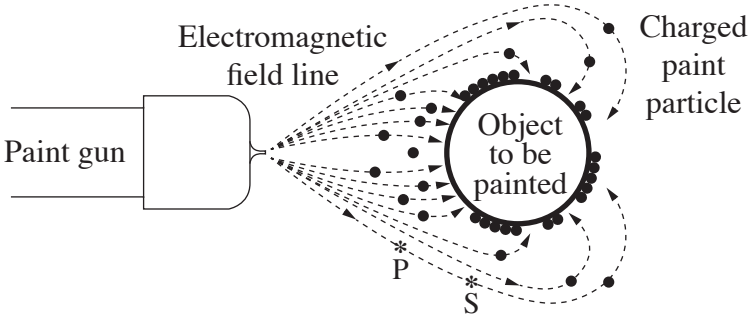
Questions

Answer three of the questions 1-5.
(Each question – $33\frac{1}{3}$ points; the point value of each item is given.)

1. To protect the environment, today, many metal factories use an electrostatic method to paint their products instead of traditional painting techniques. During the electrostatic painting process, the paint gun sprays a paint powder made up of particles that become electrically charged as they are sprayed. The paint particles stick to the object to be painted, which is a charged metal object.

The diagram below shows a painting system in which the object that is being painted is a charged metal sphere.

The arrows in the diagram represent the direction of the electromagnetic field lines in the area in which the work is being performed. The gravitational force is negligible.



א. Define the term "electromagnetic field line". ($6\frac{1}{3}$ points)

ב. Refer to the figure and determine whether the charge on the paint particles is positive or negative. Explain your answer.

(6 points)

/Continued on page 3/

A paint particle with the charge $|q| = 5 \cdot 10^{-13}$C traveled along an electromagnetic field line from Point P to Point S (see figure).

Given: The distance between P and S is d = 0.1 m.

The difference in electric potential between Point P and Point S is $|\Delta V| = 50$ kV.

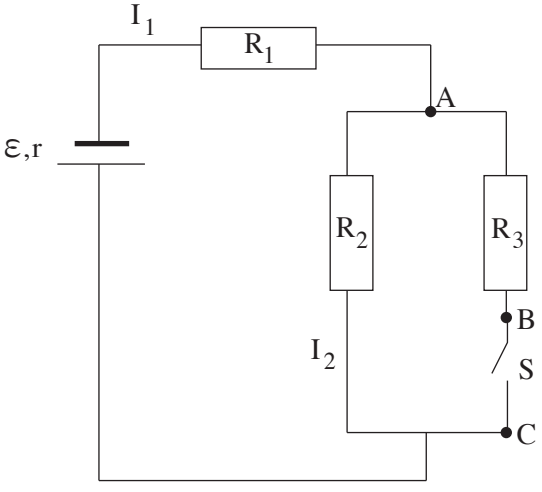
ג. At which of the two points, P or S, is the potential greater?
Explain your answer. (7 points)

ד. Assume that the electric field in the region between Point P and Point S is uniform.
Calculate the electrical force that acts on a charged paint particle as it moves from Point P to Point S.
Note: The relationship between the intensity of the uniform electric field and the difference in potential between two points within that field is defined as: $E = -\frac{\Delta V}{\Delta x}$.
(7 points)

ה. Calculate the change in the electric potential energy of the paint particle as it moves from Point P to Point S. (7 points)

/Continued on page 4/

2. The figure below shows an electrical circuit that includes a voltage source, three resistors (R_1, R_2 and R_3), a switch S and connecting wires whose resistance is negligible. The electromotive force (emf; [כא"מ]) of the voltage source is ε and its internal resistance is r. The intensity of the current flowing through Resistor R_1 is I_1 and the intensity of the current flowing through Resistor R_2 is I_2.



At first, Switch S is closed (allowing the flow of current).

א. Express the following values in terms of I_2, r, R_1, R_2 and/or R_3:

(1) I_1

(2) ε

(10 points)

ב. Given: $I_2 = 1$ A; $R_1 = 1.5$ Ω; $R_2 = 4$ Ω; $R_3 = 2$ Ω; $r = 0.5$ Ω.
Calculate the emf of the voltage source and the voltage on the terminals [מתח ההדקים] in the circuit. (6 points)

ג. Calculate the voltages V_{AB} and V_{BC}. (6 points)

Later, Switch S was opened.

ד. Calculate the voltages V_{AB} and V_{BC} in this new situation. (7 points)

ה. Is the efficiency [נצילות] of the system greater when the switch is open or when it is closed? Explain your answer. You do not need to do any calculations. ($4\frac{1}{3}$ points)

/Continued on page 5/

3. A student conducted an experiment to examine the relationship between the intensity of the current flowing through an incandescent light bulb and the voltage on the light bulb.

She built a circuit that included a voltage source, a light bulb, a fixed resistor, a variable resistor, a switch and connecting wires whose resistance was negligible (see Figure 1).

The student took several measurements using ideal measuring devices.

She presented the collected measurement data in an approximate graph that described the relationship between the two variables (current and voltage).

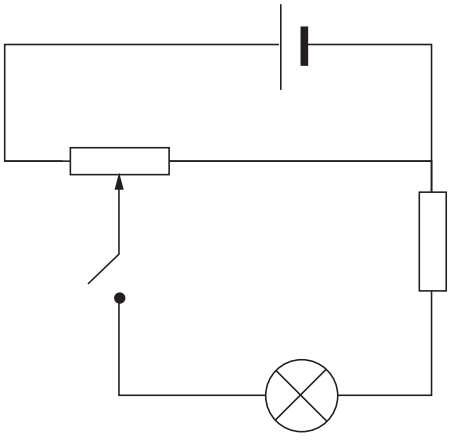


Figure 1

א. Copy Figure 1 into your answer booklet. Add the following to your drawing: an ideal voltmeter and an ideal ammeter that will measure the voltage on the light bulb and the intensity of the current flowing through the bulb.
(8 points)

(Note: This question continues on the next page.)

/Continued on page 6/

The graph that the student sketched is presented as Figure 2.

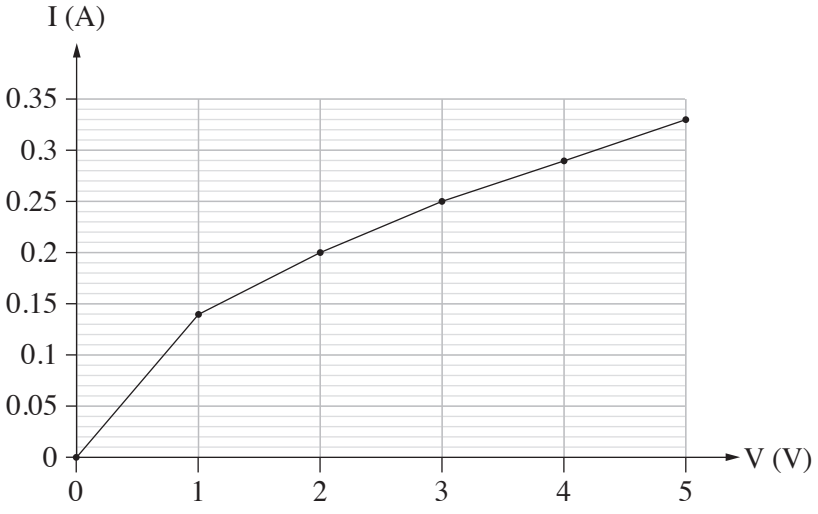


Figure 2

Based on the graph:

ב. Calculate the resistance of the bulb for <u>each</u> of the following two voltage ranges:

(1) $0 < V < 1$ V

(2) 3 V $< V < 5$ V

(8 points)

ג. Calculate the power of the bulb at <u>each</u> of the following two voltages:

(1) $V = 1$ V

(2) $V = 5$ V

(8 points)

ד. The amounts of energy <u>wasted</u> by the bulb (mainly as heat) over one second in two different situations are shown below:

(1) when $V = 1$ V, $E = 0.132$ J

(2) when $V = 5$ V, $E = 1.52$ J

Calculate the efficiency [נצילות] of the bulb for each of the <u>two</u> voltage values (1) - (2). (6 points)

/Continued on page 7/

Today, incandescent bulbs are being replaced by other types of bulbs (such as LED bulbs and PL bulbs), mainly because of the very low efficiency of incandescent bulbs.

Figure 3 (below) shows the power of PL bulbs, incandescent bulbs and LED bulbs as a function of the intensity of the light that they emit.

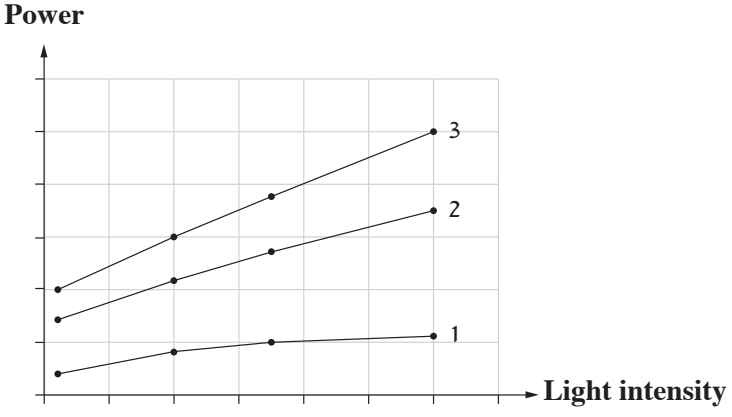


Figure 3

ה. Which one of the graphs in Figure 3 describes an incandescent bulb: 1, 2 or 3?

Explain your answer.

($3\frac{1}{3}$ points)

/Continued on page 8/

4. A student conducted an experiment to measure the magnitude of the Earth's magnetic field, B_E, in the area in which he lives.
To determine the direction of the field, he hung a magnetic needle by a thin string that was tied to the middle of the needle, in a way that allowed the needle to move freely.
α is the dip angle [זווית ההרכנה], which is the angle between the direction of the needle and the horizontal plane (see Figure 1).
The student measured the angle α and found that α = 53°. This result was affected only by the magnetic field of the Earth.

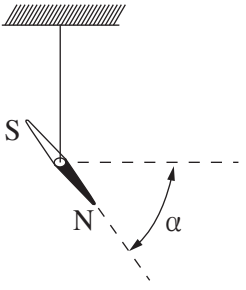


Figure 1

To measure the magnitude of the magnetic field B_E, the student constructed an electrical circuit that included a power supply, a variable resistor, an ammeter and a thin, circular coil positioned in the horizontal plane.
The student hung the magnetic needle over the center of the coil (see Figure 2).
Given: The narrow coil is made up of 4 loops (N = 4). The radius of each loop is r = 20 cm.

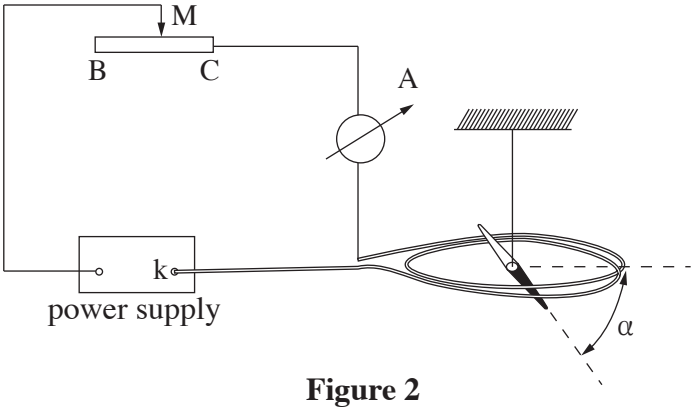


Figure 2

The student moved the wiper [הגררה] M of the variable resistor. He noticed that as he did so, the angle α became progressively smaller until, at a certain point, the magnetic needle stabilized in a horizontal position (α = 0°).

/Continued on page 9/

א. Based on the direction of the magnetic fields, is Terminal k of the power supply positive or negative? Explain your answer. (6 points)

ב. During the experiment, did the student move the wiper M of the variable resistor from Point C to Point B, or from Point B to Point C? Explain your answer. (6 points)

ג. When the needle stabilized in a horizontal position, the ammeter read: 3.2 A. Calculate the magnitude of the vertical component [הרכיב האנכי] of the Earth's magnetic field, $B_{E\perp}$. (6 points)

The student was not satisfied with the level of accuracy in his experiment and so decided to use a graph to find the vertical component of the magnetic field, $B_{E\perp}$. To do this, he repeated the measurements several times, each time changing the number of loops.
For each measurement, he wrote down the number of loops, N, and the intensity of the current, I, that was obtained when the hanging needle stabilized in a horizontal position ($\alpha = 0°$). The student calculated the $\frac{1}{I}$ values and wrote them down as well.
The results are presented in the table below.

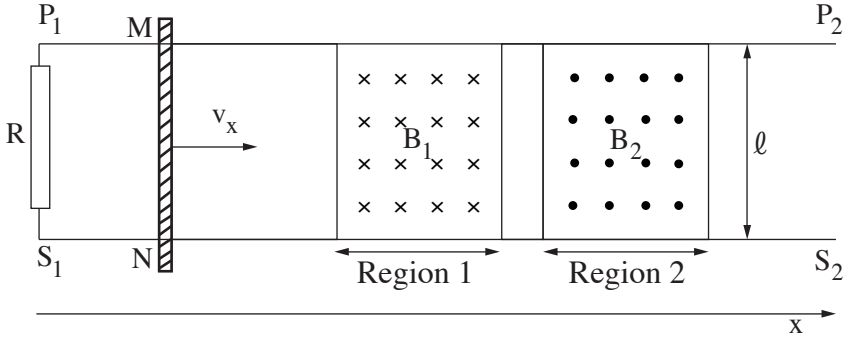
No. of loops (N)	4	6	8	10	12
I (A)	3.2	2.1	1.5	1.3	1
$\frac{\mathbf{1}}{\mathbf{I}}(\frac{1}{A})$	0.3	0.5	0.7	0.8	1

ד. In your answer booklet, sketch a graph of $\frac{1}{I}$ as a function of the number of loops, N. (9 points)

ה. Use the slope of the graph to calculate the magnitude of the vertical component of the Earth's magnetic field, $B_{E\perp}$.
($6\frac{1}{3}$ points)

/Continued on page 10/

5. The figure below depicts an experimental system, as seen from above. The system includes two smooth tracks, S_1S_2 and P_1P_2, which are positioned parallel to one another on a horizontal table top. The distance between the two tracks is ℓ (see figure).
A rod MN that has a mass m is resting on the tracks. The tracks and the rod conduct electricity and their resistances are negligible. (The air resistance is also negligible.)
Resistor R connects the P_1 and S_1 ends of the tracks.
Between the tracks in Region 1 ($0 \le x \le 0.4$ m), there is a magnetic field B_1.
Between the tracks in Region 2 ($0.5\text{ m} \le x \le 0.9$ m), there is a magnetic field B_2.
Both fields are constant, perpendicular to the plane of the table and have the same magnitude: $|B_1| = |B_2| = 0.04$ T.
The directions of the fields are indicated in the figure.
Given: $\ell = 50$ cm.
$R = 4\ \Omega$



During the experiment, the rod MN entered **Region 1** at a velocity $v_x = 2\ \frac{m}{s}$.
In this region, a force F_1 acted on the rod in the direction of the x-axis.
Therefore, the velocity of the rod remained constant.

א. As the rod moved through Region 1, did current flow through Resistor R?
If not, explain why not.
If it did, find the magnitude and the direction of that current (from S_1 to P_1 or from P_1 to S_1).
(8 points)

ב. Is the amount of work performed by the force F_1, which is necessary for the uniform motion of the rod through Region 1, greater, smaller or equal to the amount of heat that developed in Resistor R during the same period of time? Explain your answer using words or calculations.
(6 points)

/Continued on page 11/

In **Region 2**, a force F_2 acted on the rod MN in the direction of the x-axis (instead of F_1). Therefore, the rod moved with a constant acceleration $a = 5\frac{m}{s^2}$. (Note that the initial velocity of the rod in this region was $2\frac{m}{s}$.)

ג. Determine the direction of the current flowing through Resistor R (from S_1 to P_1 or from P_1 to S_1) in this situation.
(6 points)

ד. Express the intensity of the current in the resistor as a function of time. The rod entered Region 2 at the moment $t = 0$.
(8 points)

ה. Is the amount of work performed by the force F_2, which is necessary for the movement of the rod through Region 2, greater, smaller or equal to the amount of heat that developed in Resistor R during the same period of time? Explain without doing any calculations.
($5\frac{1}{3}$ points)

Good Luck!

בהצלחה!