

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: 036001, 84

Appendix: Data and formulas for 3-point Physics

English translation (3)

מדינת ישראל

משרד החינוך

סוג הבחינה:

א. בגרות לבתי ספר על-יסודיים

ב. בגרות לנבחנים אקסטרניים

מועד הבחינה: קיץ תשע"ו, 2016

מספר השאלון: 84, 036001

נספח: נתונים ונוסחאות בפיזיקה ל-3 יח"ל

תרגום לאנגלית (3)

Physics

For 3 points

Instructions for the student

א. Duration of the exam: Three hours

ב. Exam structure and breakdown of points:

This exam has three parts.

Part One – Mechanics

Part Two – Electromagnetism

Part Three – Radiation and Matter

Each part contains three questions, for a total of nine questions.

You must answer five questions only, no more than two questions from each part.

Total – $5 \times 20 = 100$ points

ג. Material that may be used during the exam:

(1) A calculator.

(2) The data and physics formulas 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. (Answers will be graded in the order they appear in the answer 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. Write the appropriate units for your answer. If you do not write out the formula, or do not insert the values, or do not indicate units, points may be subtracted from your score.

(3) In your calculations, use the value 10 m/s^2 for free-falling acceleration.

(4) 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 outside of the answer booklet may lead to the disqualification of the exam!

Good Luck!

פיזיקה

3 יחידות לימוד

הוראות לנבחן

א. משך הבחינה: שלוש שעות.

ב. מבנה השאלון ומפתח ההערכה:
בשאלון זה שלושה פרקים.

פרק ראשון – מכניקה

פרק שני – אלקטרומגנטיות

פרק שלישי – קרינה וחומר

בכל פרק יש שלוש שאלות; סה"כ – תשע שאלות.

עליך לענות על חמש שאלות בלבד:

לא יותר משתי שאלות מכל פרק.

סה"כ – $20 \times 5 = 100$ נקודות

ג. חומר עזר מותר בשימוש:

(1) מחשבון.

(2) נספח נתונים ונוסחאות 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, רשום במילים את פירושו הסימן.

לפני שאתה מבצע פעולות חישוב, הצב את

הערכים המתאימים בנוסחאות, רשום את

התוצאה שקיבלת ביחידות המתאימות.

אי-רישום נוסחה או אי-ביצוע ההצבה או

אי-רישום יחידות עלולים להפחית נקודות

מהציון.

(3) חישוביך השתמש בערך 10 m/s^2 לתאוצת

הנפילה החופשית.

(4) כתוב את תשובותיך בעט. כתיבה בעיפרון

או מחיקה בטיפקס לא יאפשרו ערעור.

מותר להשתמש בעיפרון לסרטונים בלבד.

כתוב במחברת הבחינה בלבד, בעמודים נפרדים, כל

מה שברצונך לכתוב כטיוטה (ראשי פרקים, חישובים

וכדומה). רשום "טיוטה" בראש כל עמוד טיוטה. רישום

טיוטות כלשהן על דפים שמחוץ למחברת הבחינה עלול

לגרם לפסילת הבחינה!

בהצלחה!

Questions

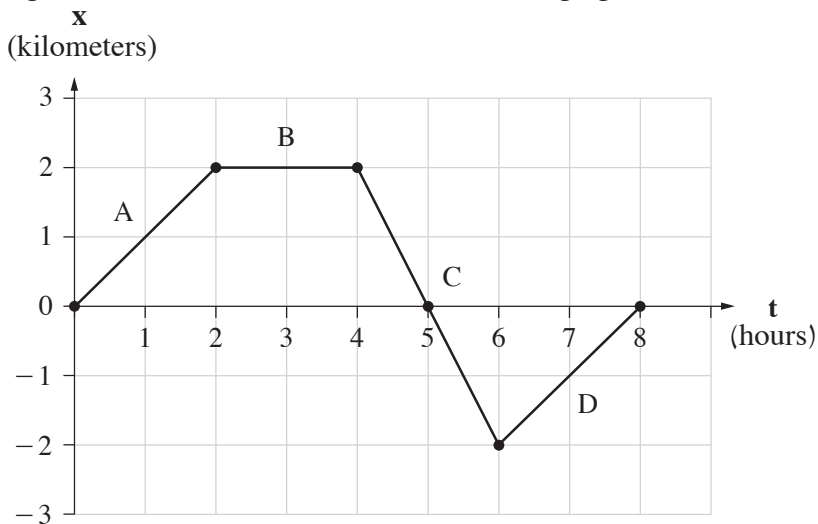
Note: You must answer five questions only: no more than two questions from each part of the exam.

Part One — Mechanics

Answer one or two questions from this part of the exam (Questions 1-3).
 (Each question – 20 points; the point value of each item is shown.)

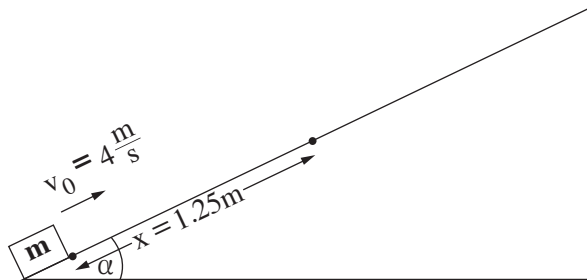
1. In the graph below, the location of a certain person is presented as a function of time over 8 hours.

At the moment $t = 0$, the person was located at the starting point $x = 0$.
 The segments A, B, C, and D are labeled on the graph.



- א. Determine the distance of the person from the starting point at $t = 8_{\text{hours}}$. (3 points)
- ב. Determine or calculate the person's average velocity during the period of time from $t = 0$ through $t = 8_{\text{hours}}$. (3 points)
- ג. (1) Calculate, or determine and explain, the person's velocity during each of the segments A, B, C, and D.
 (2) Express the person's velocity over Segment A in terms of meters per second.
 (3) Determine the person's velocity at the moment $t = 5_{\text{hours}}$. (6 points)
- ד. Determine the acceleration of the person over Segment A. Explain. (4 points)
- ה. Draw a graph of the velocity as a function of time from $t = 0$ through $t = 8_{\text{hours}}$. (4 points)

2. During an experiment, an object with a mass of $m = 3 \text{ kg}$ was pushed up an inclined plane that is not smooth (friction exists). The plane was inclined at an angle of $\alpha = 30^\circ$ relative to the horizontal (see figure). The initial velocity of the object was $v_0 = 4 \frac{\text{m}}{\text{s}}$. The object traveled up the plane until coming to a stop at a distance of $x = 1.25 \text{ m}$. The x -axis is defined as being parallel to the inclined plane, and the positive direction is upward.
- Given: Air resistance is negligible and the plane is very long.



- א. Calculate the magnitude of the acceleration of the object during its ascent. (4 points)
- ב. Copy the diagram into your answer booklet. Add arrows representing all the forces acting on the object during its ascent to the diagram in your answer booklet. Label each arrow with the name of the force that it represents. ($4\frac{1}{2}$ points)
- ג. Use Newton's second law to write an equation for the forces that are acting on the object along the x -axis. (4 points)
- ד. Use the equation that you wrote to calculate the magnitude of the frictional force, f . (4 points)
- ה. The same experiment was repeated, except this time, the inclined plane was smooth (no friction).
 Determine which of the following statements 1-4 is true. Explain your answer.
 1. The object ascended and stopped at a distance of $x < 1.25 \text{ m}$.
 2. The object ascended and stopped at a distance of $x = 1.25 \text{ m}$.
 3. The object ascended and stopped at a distance of $x > 1.25 \text{ m}$.
 4. The object ascended and did not stop at all on the inclined plane.
 ($3\frac{1}{2}$ points)

3. A ball with mass m was thrown directly upwards with an initial velocity of v_0 (see Figure $\aleph$). Air resistance is negligible.

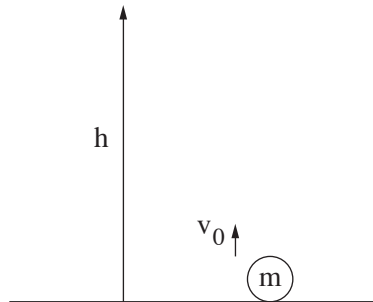


Figure $\aleph$

Two figures are shown below. Figure $\beth$ presents the potential energy (U_G) of the ball as a function of its height (h). Figure $\beth$ presents the kinetic energy (E_K) of the ball as a function of its height (h).

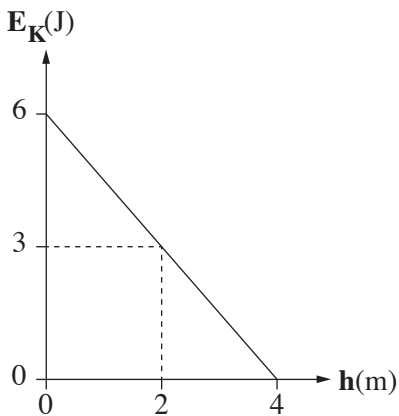


Figure $\beth$

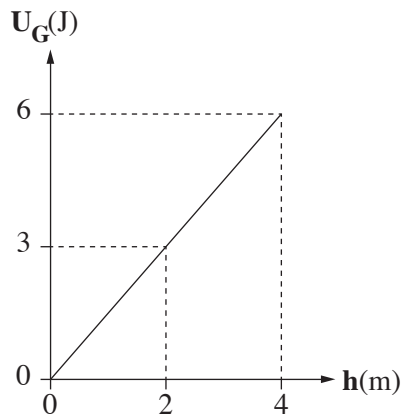


Figure $\beth$

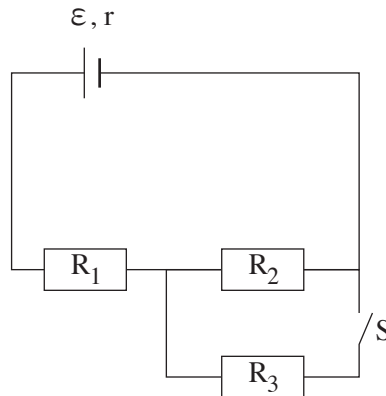
- $\aleph$. Use the graphs to determine the greatest (maximal) height that the ball reached. Explain. (4 points)
- $\beth$. Use the graphs to calculate the total mechanical energy ($E_K + U_G$) of the ball at $h = 2$ m and at $h = 4$ m. (4 points)
- γ . Determine whether any mechanical energy is wasted during the ball's ascent. Explain. (4 points)
- δ . Use Figure $\beth$ to calculate the mass of the ball. (4 points)
- ϵ . Calculate the initial velocity of the ball (v_0). (4 points)

Part Two — Electromagnetism

Answer one or two questions from Part Two (Questions 4-6).

(Each question – 20 points; the point value of each item is shown.)

4. A student built the electrical circuit shown in the figure below. The circuit includes a voltage source that has an electromotive force (emf, [כא"מ]) $\varepsilon = 12 \text{ V}$ and an internal resistance $r = 1 \Omega$, three resistors: $R_1 = 5 \Omega$, and $R_2 = R_3 = 4 \Omega$; and a switch S.



- א. Copy the diagram above into your answer booklet. Add a voltmeter that will measure the terminal voltage [מתח ההדקים] and an ammeter that will measure the current that passes through the voltage source. (4 points)

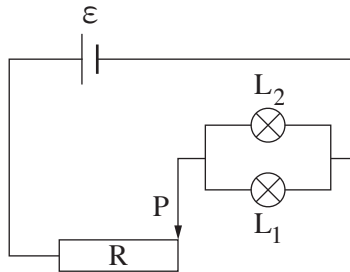
Initially, Switch S is closed (current is able to flow through it).

- ב. Calculate the intensity of the current reported by the ammeter. (4 points)
- ג. Calculate the terminal voltage reported by the voltmeter. (4 points)
- ד. Calculate the voltage on the resistor R_2 . (4 points)

Switch S is then opened (current can no longer flow through it).

- ה. (1) Determine whether the electromotive force of the voltage source increased, decreased, or remained the same. Explain.
- (2) Determine whether the terminal voltage of the voltage source increased, decreased, or remained the same. Explain. (4 points)

5. The electric circuit depicted in the figure below includes two identical light bulbs, L_1 and L_2 , a variable resistor [נגד משתנה] R and an ideal voltage source ε . Each one of the light bulbs is labeled 6 V ; 12 W. The variable resistor has a maximal resistance of 10Ω . The electromotive force [כא"מ] of the voltage source is $\varepsilon = 34.5$ V. The wiper [המגע הנייד] P is located at the edge of the variable resistor (see figure).

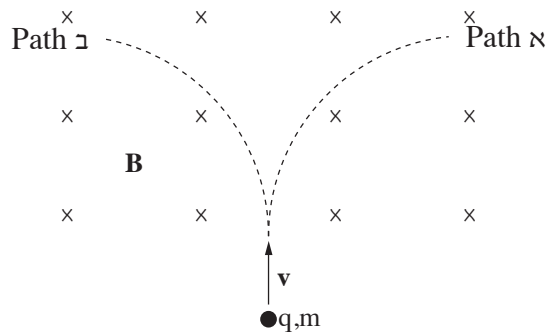


- א. Calculate the resistance of Bulb L_1 . (4 points)
- ב. Calculate the intensity of the current that flows through the voltage source. (4 points)
- ג. Calculate the power of Bulb L_1 when the current that you calculated for Item ב flows through the circuit. (4 points)
- ד. Determine whether under these circumstances the power of Bulb L_2 is greater than, less than, or equal to the power of Bulb L_1 . Explain. (4 points)

The position of Wiper P of the variable resistor is changed so that the light bulbs L_1 and L_2 shine with the power with which they are labeled.

- ה. Calculate the resistance of the variable resistor in this situation. (4 points)

6. Given: a magnetic field with a strength of $B = 0.02 \text{ T}$. The magnetic field is perpendicular to the plane of the page and is directed into the page (see figure). An electron enters the magnetic field at a velocity of $v = 7 \cdot 10^7 \frac{\text{m}}{\text{s}}$ and moves in circular motion on the plane of the page. Air resistance and the force of gravity are negligible. The mass and the charge of an electron are given on the formula sheet.



- א. Two paths, א and ב, are drawn in the diagram. Determine which of the two paths, א or ב, the electron takes. (3 points)
- ב. Calculate the magnitude of the magnetic force that acts on the electron as it moves. (5 points)
- ג. Calculate the radius of the path along which the electron moves. (4 points)
- ד. Determine whether over the course of its movement, the magnitude of the electron's velocity decreases, increases, or remains the same. Explain. (4 points)
- ה. In a different scenario, the electron enters the magnetic field with a velocity that is parallel to the direction of the field. Determine which one of the following statements, 1-3, describes the path of the electron. Explain your answer.
1. The electron moves in a straight line.
 2. The electron moves along a circular path.
 3. The electron moves along some other path.
- (4 points)

Part Three — Radiation and Matter

Answer one or two questions from Part Three (Questions 7-9).

(Each question – 20 points; the point value of each item is shown.)

7. A student conducted three experiments. In the first experiment, a narrow beam of light (a ray of light) hit the plane MN, which separated two transparent substances. The indexes of refraction [מקדמי השבירה] of the substances are n_1 and n_2 . Given: $n_1 > n_2$.
- א. For each of the four diagrams below, 1א - 4א, determine whether the path of the ray is possible. Explain your answers. (4 points)

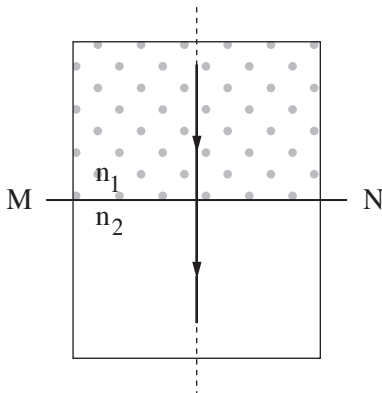


Figure 2א

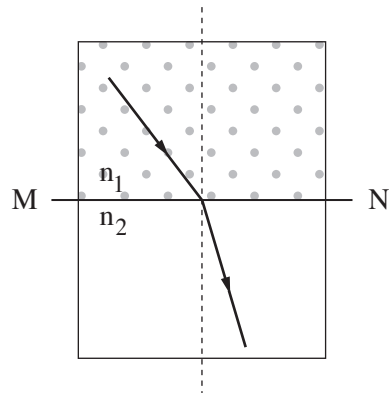


Figure 1א

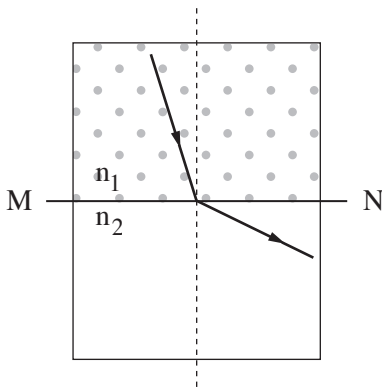


Figure 4א

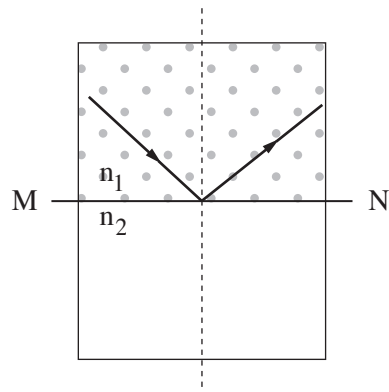


Figure 3א

In the second experiment, a ray of light traveled from the air ($n = 1$) into a different transparent medium.

Given: the angle of incidence $\alpha = 39^\circ$ and the angle of refraction $\beta = 20^\circ$ (see Figure ב).

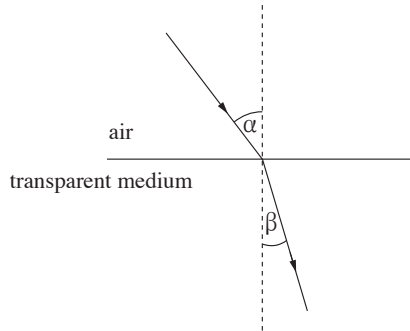


Figure ב

- ב. Calculate the index of refraction [מקדם השבירה] of the transparent medium. (6 points)
- ג. Calculate the critical angle of the light as it passed from the transparent medium into the air. (6 points)

In the third experiment, the light traveled through a transparent medium that was identical to the transparent medium in the second experiment. The light hit the plane which separated that medium and the air at an angle of incidence of $\alpha = 39^\circ$ (see Figure ג).

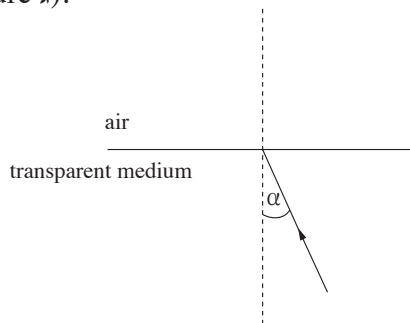
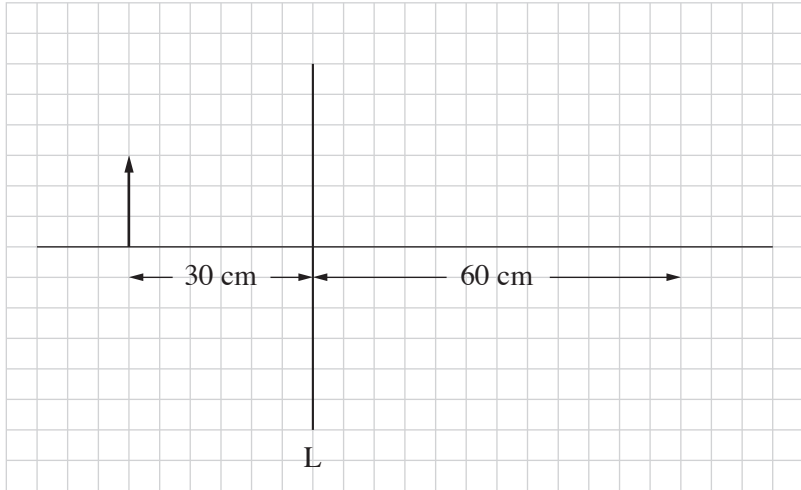


Figure ג

- ד. Determine whether the light passed into the air or was reflected back into the transparent medium in this experiment.
If the light passed into the air, calculate the angle of refraction.
If the light was reflected back into the transparent medium, determine the size of the angle of reflection [זווית ההחזרה] and explain your answer. (4 points)

8. An object with a height of 15 cm is placed perpendicularly to the principal axis [ציר אופטי] of a lens L, at a distance of 30 cm from the lens. The image of the object appears on a screen located 60 cm away from the lens (see figure).



- א. Determine whether the obtained image is real or virtual. Explain. (4 points)
- ב. Determine whether the lens is a converging lens [עדשה מרכזת] or a diverging lens [עדשה מפזרת]. (4 points)
- ג. Calculate the height of the obtained image. (4 points)
- ד. Calculate the focal length [אורך המוקד] of the lens. (4 points)
- ה. Copy the diagram above into your answer booklet in the same scale: every square represents 5 cm. In your drawing, sketch the image of the object with the help of principal rays [קרניים אופייניות] that are emitted from the top of the object. (4 points)

9. After a guitar string is plucked, the string vibrates at a frequency of $f = 330 \text{ Hz}$. At this frequency, the wavelength of the wave which is created on the string is $\lambda = 1.32 \text{ m}$.
- א. Determine whether the wave that is created on the string is a longitudinal wave [גל אורך] or a transverse wave [גל רוחב]. Explain your answer. (4 points)
- ב. Calculate the speed at which the wave propagates along the string. (5 points)
- ג. Determine whether the frequency of the wave is dependent on the strength with which the string is plucked (the amplitude of the string). (3 points)

The vibrating string creates waves that propagate through the air. The speed of the waves that propagate through the air is known to be different from the speed of the waves that propagate along the string (which you calculated in Item ב).

- ד. Determine whether the frequency of the wave that propagates through the air is the same as the frequency of the wave that propagates along the string. (3 points)

A rope is presented in the diagram below. On the rope, there are two pulses that are traveling toward each other. One pulse is triangular and the other pulse is rectangular. The maximal point of the triangular pulse is labeled with the letter A and the middle point of the rectangular pulse is labeled with the letter B. When the two pulses meet, superposition occurs.



- ה. In your answer booklet, sketch a diagram that shows the shape of the rope at the moment at which the two points, A and B, are in the same place on the rope. Make sure that the scale of your sketch is the same as the scale in the diagram above (one square in the diagram = one square in your answer booklet). (5 points)

Good Luck!

בהצלחה!