State of Israel
Ministry of Education
Type of exam: *Bagrut*
Exam date: Summer 2025
Exam number: 36361
Attachment: Formula and data sheets for 5-point Physics
English translation (3)

מדינת ישראל
משרד החינוך
סוג הבחינה: בגרות
מועד הבחינה: קיץ תשפ"ה, 2025
מספר השאלון: 36361
נספח: דפי נוסחאות ונתונים בפיזיקה ל-5 יח"ל
תרגום לאנגלית (3)

Physics
Mechanics

Instructions

א. Duration of the exam: Two hours.

ב. Exam structure and breakdown of points:
This exam has six questions. Answer three questions only.

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 non-graphing calculator. You may not use the programming options of a programmable calculator.
(2) Formula and data sheets (attached)
(3) A Hebrew–foreign language / foreign language–Hebrew dictionary

ד. Special instructions:
(1) Answer three questions only. If you answer more than three questions, only the first three answers in your answer booklet will be graded.
Clearly indicate the question and item number that you chose.
(2) When solving questions that require calculations, you must show the following steps: Write down the mathematical expression as it appears in the formula and data sheets; write down all derivations and change in subject of the formula required by the problem; insert the data in the derived expression; write the results of your calculations in decimal form to a suitable number of significant figures and suitable units of measurement.
(3) Use at least half a page for drawing graphs. Use a ruler to draw straight lines.
(4) When asked to express a magnitude using data from the question, write a mathematical expression that includes some or all of the data given in the question. If necessary, you may also use basic constants from the table in the formula and data sheets, or the free-fall acceleration g.
(5) In your calculations, use the value 10 m/s² for the magnitude of g, free-fall acceleration (near the surface of Earth).
(6) Write your answers in pen. You may use pencil for sketches and graphs only.
(7) If you make a mistake, it is sufficient to cross out the incorrect text with a double line.

Write in the answer booklet only. Write "טיוטה" at the top of each draft page. If you write any draft material on pages not in the answer booklet, your exam may be disqualified.

Good Luck!

פיזיקה
מכניקה

הוראות

א. משך הבחינה: שעתיים.

ב. מבנה השאלון ומפתח ההערכה:
בשאלון זה שש שאלות, ומהן יש 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 לא גרפי. אין להשתמש באפשרויות התכנות במחשבון שיש בו אפשרות תכנות.
(2) דפי נוסחאות ונתונים (מצורפים).
(3) מילון עברי–לועזי / לועזי–עברי.

ד. הוראות מיוחדות:
(1) יש לענות על שלוש שאלות בלבד. אם תענו על יותר משלוש שאלות, ייבדקו רק שלוש התשובות הראשונות שבמחברת.
יש לציין באופן ברור את מספר השאלה שבחרתם ואת הסעיף.
(2) בשאלות שבפתרון שלהן נדרש חישוב, יש להציג את השלבים האלה: רישום הביטוי המתמטי כפי שהוא כתוב בדפי הנוסחאות והנתונים המצורפים, פיתוח מתמטי ושינוי נושא נוסחה בהתאם לבעיה, הצגה מפורשת של הנתונים בביטוי שהתקבל, הצגת תוצאות החישוב באמצעות שבר עשרוני ובו מספר מתאים של ספרות משמעותיות וכן יחידות המידה.
(3) את הגרפים יש לסרטט בגודל של חצי עמוד לפחות. יש להשתמש בסרגל לסרטוט קווים ישרים.
(4) כאשר נדרשים להביע גודל באמצעות נתוני השאלה, יש לרשום ביטוי מתמטי הכולל את נתוני השאלה או את חלקם; במידת הצורך אפשר להשתמש גם בקבועים בסיסיים מתוך הטבלה שבדפי הנוסחאות והנתונים או בגודל תאוצת הנפילה החופשית g.
(5) בחישובים יש להשתמש בערך $10\ \mathrm{m/s^2}$ לגודל של g — תאוצת הנפילה החופשית (בסמוך לפני כדור הארץ).
(6) יש לכתוב את התשובות בעט. מותר להשתמש בעיפרון לסרטוטים וגרפים בלבד.
(7) במקרה של טעות, אפשר להסתפק בהעברת קו חוצה כפול על המילים או המשפטים השגויים.

יש לכתוב במחברת הבחינה בלבד. יש לרשום "טיוטה" בראש כל עמוד המשמש טיוטה. כתיבת טיוטה בדפים שאינם במחברת הבחינה עלולה לגרום לפסילת הבחינה.

בהצלחה!

Questions

Answer three of the questions 1–6.

(Each question – $33\frac{1}{3}$ points; the point value of each item is given at the end of the item.)

1. In the 22nd Maccabiah scheduled to take place in Israel in the summer of 2026, one of the athletic events will be the javelin throw.

Israeli athlete Ariel Attias, who won a gold medal for the javelin throw in the 21st Maccabiah, threw his javelin twice during a training session. An electronic system tracked his javelin's motion from the moment it reached its peak height until it struck the ground, and provided data about the javelin's motion.

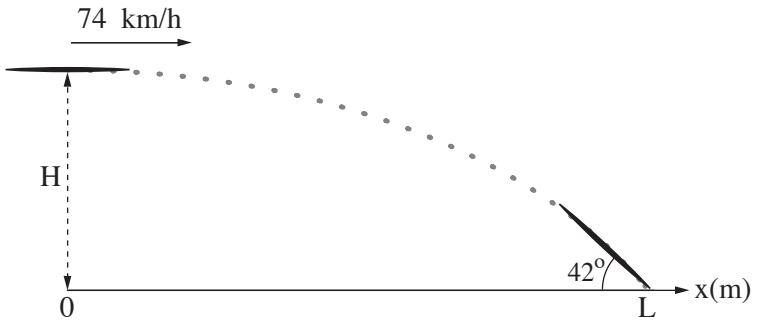
First throw:

The electronic system began sampling the javelin's motion at the time $t = 0$; at that moment the javelin was at its peak height, H meters above the point on the ground that had been defined as the origin of the location axis, $x = 0$.

We know that: At its peak height, H , the javelin's horizontal velocity was 74 km/h .

The javelin tip touched the ground at $x = L$ at an unknown speed, at an angle of $42°$ (see figure).

The javelin's friction with the air as it moved is negligible. Assume in your calculations that the javelin is a point object.



א. Describe in words the features of the javelin's motion, from the moment the system started tracking its motion (the moment the javelin reached peak height) until the moment it struck the ground. In your answer, discuss each of the two axes of motion separately. (8 points)

ב. Calculate the speed of the javelin at the moment it struck the ground. (8 points)

ג. Calculate H , the maximum height of the javelin trajectory. (7 points)

Second throw:

The javelin's peak height in the second throw was 1 meter lower than the peak height in the first throw (the height you calculated in Item ג), and its velocity was not 74 km/h. However, the horizontal distance, L , that the javelin travelled from the moment it reached peak height until the moment it struck the ground was identical in both throws.

ד. Calculate the horizontal velocity of the javelin at the peak height of the second throw. (6 points)

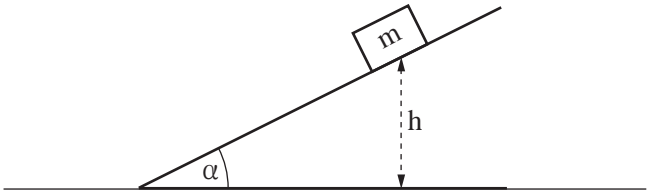
ה. Without calculating, determine whether the angle of impact with the ground in the second throw was smaller, larger, or equal to the angle of impact in the first throw. Explain your answer. ($4\frac{1}{3}$ points)

/Continued on page 3/

2. A small object of mass m is lying at a height of h on an inclined plane with an adjustable angle α (see figure).

When the angle is α_0 the object is at rest.

The coefficient of static friction between the object and the plane is μ_s, and the coefficient of kinetic friction is μ_k.



א. Sketch a free-body diagram [תרשים כוחות] of the forces acting on the object. Label each force with its name and specify what exerts the force. (6 points)

The angle of the inclined plane was **reduced** to an angle of α_1 which satisfies $\alpha_0 > \alpha_1$.

ב. Determine whether the magnitude of the force of friction exerted on the object increased, decreased, or remained the same after the angle was reduced. Explain your answer. (7 points)

The angle of the inclined plane was **increased** to an angle of α_2, at which the object is **on the verge of moving**.

ג. **(1)** Give the <u>two</u> equations of the forces exerted on the object when it is on the verge of moving.

(2) Express the size of the angle α_2 as a function of the data in the question. (8 points)

The angle of the inclined plane was **increased again** to an angle of α_3, at which the object moves down the inclined plane.

We know that: $\mu_k = 0.24$

$\alpha_3 = 22^o$

$h = 0.3m$

ד. Calculate the speed of the object at the moment it reaches the bottom of the inclined plane. (8 points)

The object is given an initial velocity up the inclined plane. Let a_u be the magnitude of the object's acceleration when it moves up the inclined plane, and let a_d be the magnitude of its acceleration when it moves down the inclined plane.

ה. Look at Diagrams 1–3 below showing qualitative charts of the magnitude of the object's accelerations going up and down as a function of time, t. Determine which diagram <u>correctly</u> describes the magnitude of the object's acceleration going up and down the slope. ($4\frac{1}{3}$ points)

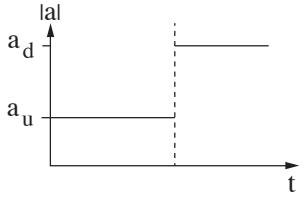


Diagram 1

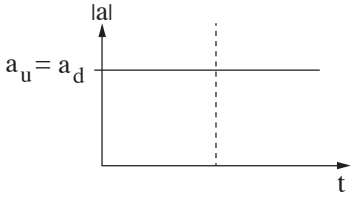


Diagram 2

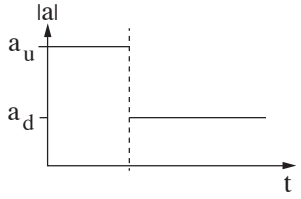
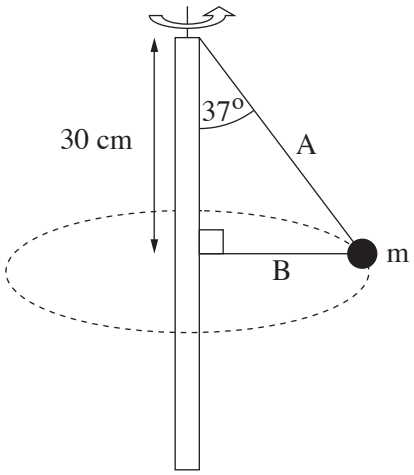


Diagram 3

/Continued on page 4/

3. A small ball of mass $m = 0.2kg$ is attached to a vertical pole by two strings, A and B.
String A is attached to the top of the pole, and String B is attached to the pole at a point 30 cm below the point where String A is attached.
We spin the vertical pole so that the ball revolves in a circle on a horizontal plane and String B remains horizontal all the while that the ball is in motion (see figure).



We know that while the ball is revolving, the tension in **String B** is $T_B = 3N$, and the angle between String A and the pole is $37°$.

א. Sketch a free-body diagram [תרשים כוחות] of the forces exerted on the ball while it is revolving. (5 points)

ב. Calculate the tension in String A, T_A. (5 points)

ג. Calculate the frequency of revolution (f). (7 points)

ד. Determine whether the tension T_A is exerting work on the ball as it revolves along one quarter of a circle. Explain your answer. (6 points)

We want to bring the tension in String B to zero ($T_B = 0$), while maintaining the ball's circular motion such that the angle between String A and the pole remains $37°$.

ה. Determine whether in order to do this the frequency of revolution (f) must be increased, decreased, or left unchanged. Explain your answer. (6 points)

The frequency of revolution was **increased** such that the ball revolved on the same circular path but at a greater velocity.

ו. Determine whether the magnitude of the tension T_A changed after the frequency of revolution was increased. Explain your answer. ($4\frac{1}{3}$ points)

/Continued on page 5/

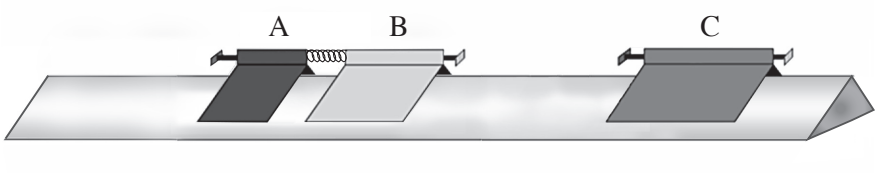
4. Consider a system consisting of a smooth horizontal track on which there are three objects A, B, and C of masses m_A, m_B, and m_C, respectively. Objects A and B are held together by a compressed spring (see figure).

In your answers you will ignore the energy of the spring.

The friction forces between the objects and the track are negligible.

We know the following: $m_A = 0.1kg$, $m_B = 0.2kg$, the mass of the spring is negligible.

Objects A and B and the compressed spring between them move to the right as a single unit at a velocity of $v = 0.6\frac{m}{s}$.



א. Explain why Object A, Object B, and the spring in between them form a closed system. (6 points)

At a certain moment, the spring released and separated from the objects; as it released it exerted a force on the two objects such that they separated from each other: Object A stopped, and Object B continued moving.

ב. Calculate the velocity u_B of Object B (magnitude and direction) immediately after the objects A and B separated. (8 points)

ג. Calculate the work exerted on Object A while it was separating. (8 points)

After separating, Object B continued moving and had a one-dimensional elastic collision with Object C, which was at rest on the track.

After the collision, Object B moved in the direction opposite to its motion before the collision, and its speed was reduced by a factor of 2.

ד. Calculate u_C, the speed of Object C after it collided with Object B. (7 points)

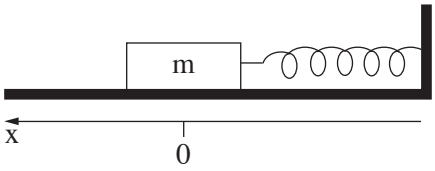
ה. Calculate m_C, the mass of Object C. ($4\frac{1}{3}$ points)

/Continued on page 6/

5. Simple harmonic motion is a periodic motion that satisfies the formula $\Sigma\vec{F} = -c\vec{x}$.

א. Determine whether **all** periodic motions are simple harmonic motions.
If so, explain your answer.
If not, provide an example of a periodic motion which is not simple harmonic motion.
(5 points)

Some students conducted two experiments with an object of mass $m = 0.5kg$. The object is placed on a frictionless horizontal table and is attached to the wall with a horizontal spring (see figure).
In their first experiment, the students shifted the object to the left in the positive direction of the location axis, x , to a distance of 60 cm from the equilibrium position ($x = 0$).
They released the object so that it oscillated right and left in simple harmonic motion, and used a sensor to measure the magnitude of the force F that the spring exerted on the object as a function of its location x .



The students' measurements are shown in the table below.

x(cm)	60	40	20	0	−10	−30	−50
F(N)	−9.4	−6.5	−3.0	0	1.7	5.0	7.8

ב. **(1)** Sketch a scatter diagram (dots on a coordinate system) of the force F as a function of the object's location x .
(2) Add the best regression line [קו המגמה] to your scatter diagram.
(8 points)

ג. Use the graph you drew to calculate the angular velocity, ω , of this object's motion.
(8 points)

ד. What is the object's location, x , at the point at which it is moving at maximum velocity?
Calculate its velocity (magnitude) at this point. (8 points)

In the second experiment, the object was at rest at the equilibrium position ($x = 0$). The students gave it an initial velocity to the left which was 2 times greater than the velocity you calculated in Item ד.

ה. Determine whether the frequency of oscillation of the object in the second experiment was greater than, less than, or equal to its frequency of oscillation in the first experiment. Explain your answer. ($4\frac{1}{3}$ points)

/Continued on page 7/

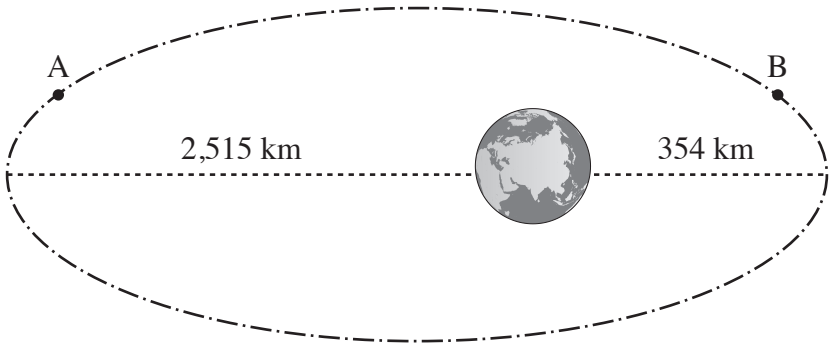
Gravity

6. The Explorer 1 satellite was developed by the Jet Propulsion Laboratory in Pasadena, California. It was launched in 1958 and is considered the first satellite to be successfully launched into space by the United States.

The 14 kg satellite orbited Earth in an elliptical orbit whose maximum height above the surface of Earth was 2,515 km and minimum height above the surface of Earth was 354 km (see figure).

Note: The figure is not drawn to scale.

Assume that the only force affecting the satellite's motion is Earth's gravitational force.



א. A and B are two points on the satellite's orbit. Determine whether when the satellite passes through Point A on the elliptical orbit shown above, its speed is greater than, smaller than, or equal to its speed when passing through Point B . Explain your answer. (8 points)

ב. Determine whether any work is done by the gravitational force as the satellite travels between Point A and Point B . Explain your answer.
(8 points)

A second given satellite of identical mass is orbiting Earth in a circular orbit, completing one revolution in 100 minutes.

ג. Calculate the radius of this satellite's orbit. (8 points)

ד. Calculate the work required to move this satellite into a different circular orbit that is 1,000 km higher than its previous orbit. (5 points)

ה. Determine whether the orbital period of this satellite in its second orbit is equal to, shorter, or longer than 100 minutes. Explain your answer. ($4\frac{1}{3}$ points)

Good Luck!

בהצלחה!

All rights reserved by the State of Israel.
No part of this document may be copied or disseminated without the permission of the Ministry of Education.

זכות היוצרים שמורה למדינת ישראל
אין להעתיק או לפרסם אלא ברשות משרד החינוך