State of Israel
Ministry of Education
Type of exam: *Bagrut*
Exam date: Summer 2026
Exam number: 36361
Attachment: Formula and data sheets for Physics
English translation (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) Physics formulas and data (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, structure your answer as follows: Write down the mathematical expression as it appears in the attached 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!

מדינת ישראל
משרד החינוך
סוג הבחינה: בגרות
מועד הבחינה: קיץ תשפ"ו, 2026
מספר השאלון: 36361
נספח: דפי נוסחאות ונתונים בפיזיקה
תרגום לאנגלית (3)

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) נוסחאות ונתונים בפיזיקה (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 $10\ m/s^2$ 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!

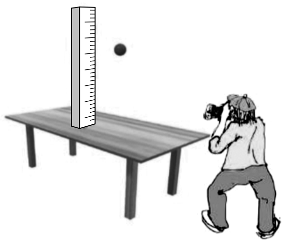
Questions

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. Some students examined the motion of a ball bouncing off a horizontal table. They released the ball from a certain height and photographed its motion from the moment it struck the table. To determine the ball's position, $y(t)$, they placed a vertical ruler behind it. The plane of the table was defined as the origin of the vertical axis ($y = 0$).

Air resistance is negligible.



The results of the students' measurements are shown in Table A.

t(s)	0.00	0.04	0.08	0.12	0.16	0.20	0.24	0.28	0.32	0.36	0.40
y(m)	0	0.11	0.20	0.29	0.35	0.40	0.43	0.45	0.45	0.43	0.40

Table A

א. Use the measurements in Table A to calculate the ball's velocity (magnitude and direction) at the time $t = 0.08$ s. (6 points)

ב. Copy Table B to your answer booklet. Fill in the missing values based on the measurements in Table A. There is no need to provide detailed calculations. (7 points)

t(s)	0.08	0.12	0.20	0.28	0.32	0.36
v(m/s)						

Table B

ג. Use the measurements in Table B to draw a scatter diagram of the ball's velocity (v) as a function of time (t). Add a regression line to your diagram. (8 points)

ד. Based on the regression line you drew:

(1) Determine the ball's speed (magnitude of the velocity) as it bounced off the table (in other words, the initial speed at which the ball bounced back up from the table).

(2) Calculate the acceleration of the ball (magnitude and direction).

(8 points)

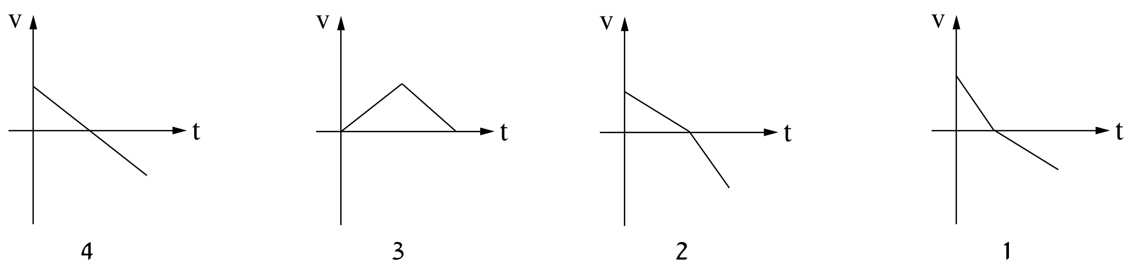
(Note: This question continues on the next page.)

/Continued on page 3/

In Item ה, air resistance is **not negligible** and it is approximately constant.

ה. One of the figures 1–4 below is a qualitative description of the ball's velocity (v) as a function of time (t), when air resistance is not negligible.

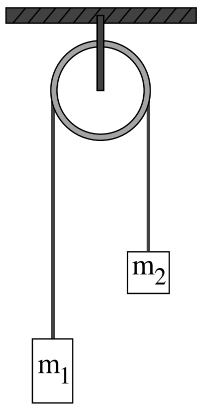
Determine which of the figures 1–4 correctly describes the ball's velocity. Explain your answer. ($4\frac{1}{3}$ points)



/Continued on page 4/

2. An Atwood machine is a device for studying uniformly accelerated motion. It was invented by the English physicist and mathematician George Atwood (1745–1807) in 1784.

Some high school physics students assembled a device that resembled an Atwood machine. Their device consisted of a pulley mounted on the ceiling, a string around the pulley, and two masses, m_1 and m_2 tied to the string, as shown in the figure.



We know that:

- $m_1 > m_2$;
- the length of the string is constant and the masses m_1 and m_2 do not reach the floor or the pulley;
- air resistance, friction in the pulley axis, pulley mass, and string mass are negligible.

א. Copy the figure to your answer booklet and mark the forces exerted on each of the masses. Label each force in the diagram with its name and the component exerting the force.
(5 points)

Students wrote several expressions to describe the system's acceleration, including the following expressions:

(i) $a = \frac{m_1}{m_2} g$ (ii) $a = \frac{m_1}{m_2^2} g$

ב. Their teacher immediately rejected both expressions (i) and (ii).

(1) Determine what physical argument should be used to reject Expression (i) even before the correct expression is found.

(2) Determine what physical argument should be used to reject Expression (ii) even before the correct expression is found.

(8 points)

ג. Express the system's acceleration in terms of the masses m_1 and m_2 and physical constants.
(8 points)

ד. When the system was released from rest, the mass m_1 traveled a distance of 1 m in the first second of its motion.
Calculate the ratio between the masses, $\frac{m_1}{m_2}$. (8 points)

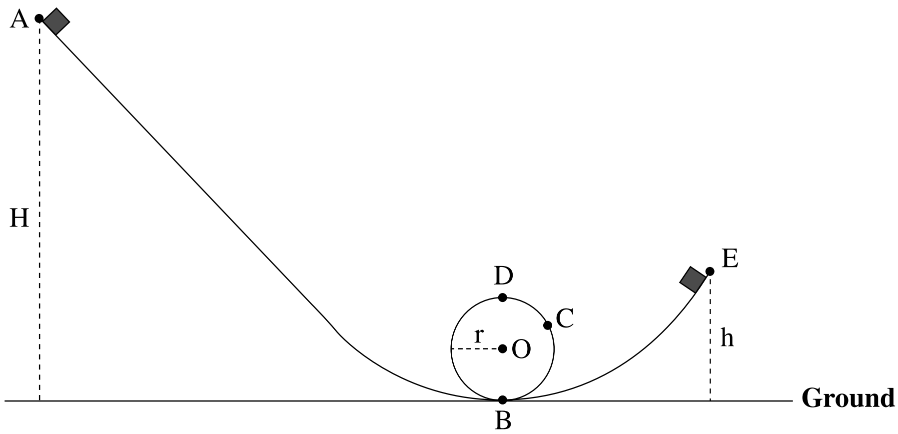
ה. During the experiment, the masses moved at a constant acceleration. The mass m_1 moved downwards and the mass m_2 moved upwards.
Explain why the magnitude of the acceleration was the same for both masses. ($4\frac{1}{3}$ points)

/Continued on page 5/

3. Consider a smooth track ABCDE . Points A and E are the ends of the track. The track contains a circular, vertical loop of radius $r = 10$ cm and center O . Point D is the highest point of the loop (see figure).

A small object is released from rest at Point A , whose height is H above the ground. The object travels along the track and continues moving after it passes the end of the track, E , whose height is h .

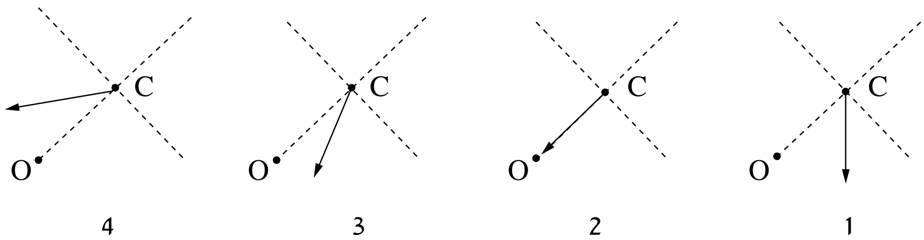
Air resistance is negligible.



We know that $h = 30$ cm . The velocity of the object at Point E is $v_E = 4\frac{m}{s}$ in the direction $\alpha = 37^o$ above the horizon.

א. Calculate the height above the ground (H) of Point A , from which the object was released. (6 points)

ב. Consider the four diagrams 1–4. Determine which diagram correctly describes the direction of the object's acceleration vector as it passed through Point C (see figure). Explain your answer. (7 points)



ג. Calculate the impact velocity (magnitude and direction) of the object when it strikes the ground after leaving the track at Point E . (7 points)

ד. In another test, the object is released from rest from a height H_1 . We know that $H_1 < H$.

(1) Draw a free-body diagram of the forces exerted on the object as it passes through Point D .

(2) Calculate the <u>minimum</u> height H_1 from which the object should be released to prevent it from detaching from the track as it travels the loop. (9 points)

The object is released from rest at Point A .

ה. Determine whether the maximum height above the ground that the object reached as it traveled (after leaving the track) is higher than, smaller than, or equal to H . Explain your answer (there is no need to provide calculations). ($4\frac{1}{3}$ points)

/Continued on page 6/

4. Consider a track ABC composed of an inclined plane AB and a horizontal plane BC (see Figure 1).
Four experiments are conducted. In each experiment, a small object of mass $m = 100$ g is placed at Point C , and given an initial velocity of $v_0 = 4\frac{m}{s}$ in the direction of Point B . The object passes through Point B and continues up the inclined plane.
Air resistance is negligible.

א. **In the first experiment only**, the frictional force between the object and the track is negligible. Calculate h , the height of Point A at which the object stops momentarily. (6 points)

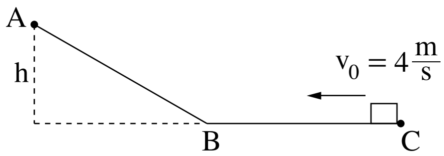


Figure 1

In the following items, the frictional force between the object and the track is **not negligible**.
In the second experiment, the object stops momentarily at Point A_1 whose height is 20% lower than the height of Point A (see Figure 2).

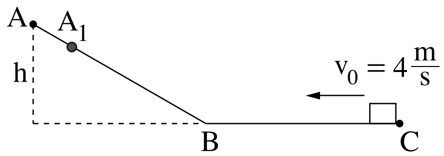


Figure 2

ב. Calculate the work of the frictional force as the object moves from Point C to Point A_1 in the **second experiment**. (7 points)

ג. Calculate the speed of the object as it passes again through Point C in the **second experiment**. (7 points)

In the **third experiment**, an external force F acts on the object throughout its movement from Point C to Point A_1 . The force F is of constant magnitude and its direction is identical to the **direction of the object** at all times (see Figure 3).

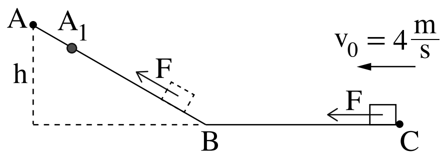


Figure 3

We know that the speed of the object when it reached Point A_1 is the same as its initial speed ($4\frac{m}{s}$).

ד. Calculate the work of the external force F as the object traveled from Point C to Point A_1 in the **third experiment**. (9 points)

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

/Continued on page 7/

In the **fourth experiment**, an external force F acts on the object throughout its movement from Point C onwards. The magnitude of the force F is identical to the magnitude of the force in the third experiment, and it is directed horizontally to the left at all times (see Figure 4).
We know that the object reached a speed of $4\frac{m}{s}$ as it traveled up the inclined plane.

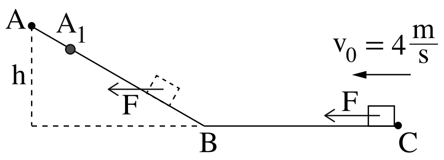


Figure 4

ה. Determine whether the object in the **fourth experiment** reached a speed of $4\frac{m}{s}$ in its movement up the inclined plane before Point A_1, at Point A_1, or after Point A_1. Explain your answer.
($4\frac{1}{3}$ points)

/Continued on page 8/

5. An object of mass M is placed on a smooth, horizontal floor. The object is tied to a string of length L which is attached to the wall of the room (see top view in the figure below).

A projectile is fired at the object three times. Each time, the projectile strikes the center of the object at a horizontal velocity that is perpendicular to the string.

The projectile penetrates the object and remains embedded in it.

The time it takes the projectile to penetrate the object is very short.

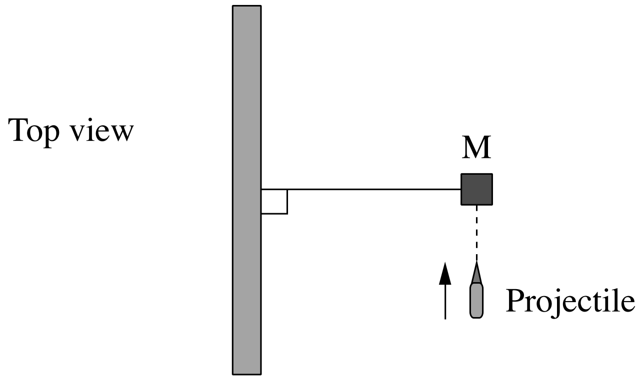
The mass of the object in each round is M .

The mass and speed of the projectile in each round is as follows:

In the first round, the projectile is of mass m and it strikes the object at a speed v .

In the second round, the projectile is of mass $2m$, and it strikes the object at a speed $0.5v$.

In the third round, the projectile is of mass $0.5m$, and it strikes the object at a speed $2v$.



א. Determine whether mechanical energy was conserved during the collision in the first round. (5 points)

ב. Express the common speed of the object and the projectile, immediately after the collision in each of the three rounds, in terms of the data provided in the question. (9 points)

We know that after each collision the object and the projectile travel in a circular motion.

ג. Express the tension in the string during this motion in each of the three rounds. (9 points)

ד. Determine in which of the three rounds the chance that the string will break after the impact is greatest. Explain your answer. (6 points)

ה. Determine whether momentum is conserved during a quarter turn of the object with the projectile inside it, before they strike the wall. Explain your answer. ($4\frac{1}{3}$ points)

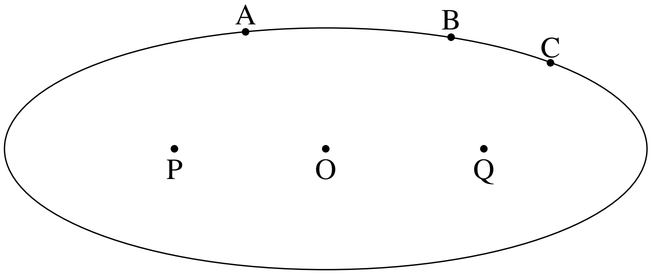
/Continued on page 9/

Gravitation

6. Several satellites orbit an imaginary planet of mass M and radius R .

One of the satellites orbiting the planet travels in an elliptical path.

Points A , B , and C are marked on the satellite's orbit. Points P and Q are the foci of the ellipse, and Point O is its center (see figure).



The satellite takes the same length of time to travel from Point A to Point B as it does from Point B to Point C .

א. Determine at which of the given points the imaginary planet is located. Explain your answer. (7 points)

The imaginary planet has two more satellites. These two satellites have the same mass and orbit the planet in a **circular path**.

The orbital radii of the satellites' paths around the center of the planet are R_1 and R_2 .

We know that $R_2 = 2R_1$.

ב. Consider the following three statements. Determine whether <u>each</u> statement is true or false.

(1) Both satellites have the same kinetic energy.

(2) The total mechanical energy of the satellite whose orbital radius is R_2 is greater than that of the satellite whose orbital radius is R_1 .

(3) During the satellites' circular motion, the gravitational force acting on the satellite whose orbital radius is R_2 is 2 times greater than the gravitational force acting on the satellite whose orbital radius is R_1 .

(9 points)

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

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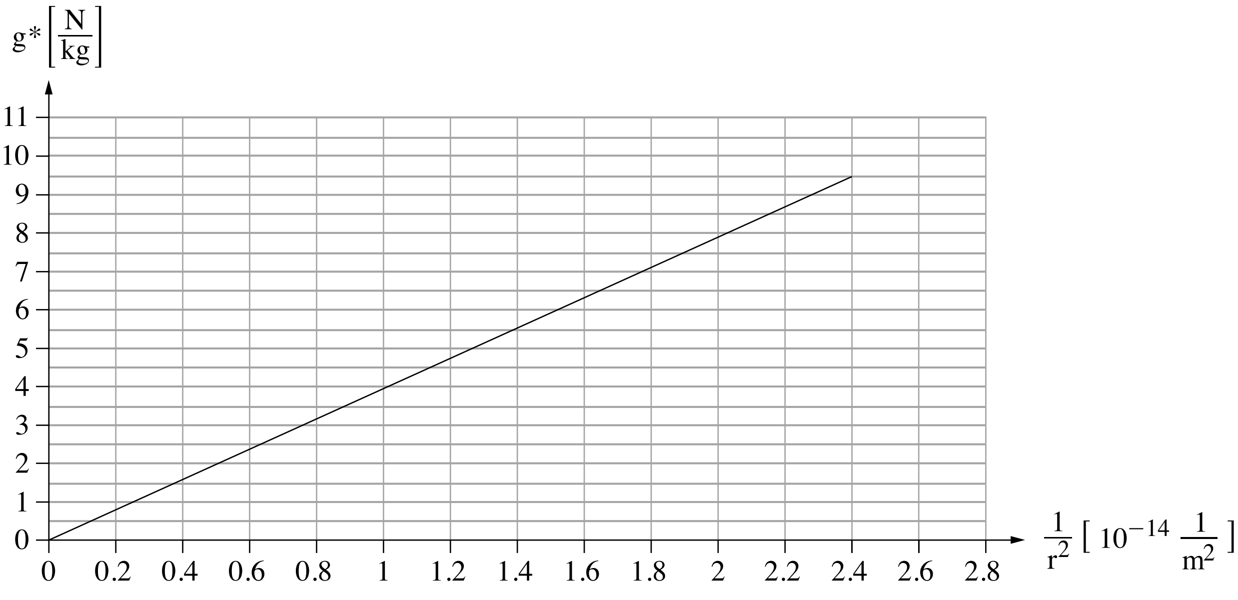
The graph below describes the intensity of the gravitational field, g^*, as a function of $\frac{1}{r^2}$, for $r \geq R$. r is the distance from the center of the planet.



ג. Calculate the mass M of the imaginary planet. (8 points)

ד. Express the magnitude of the escape velocity from the imaginary planet's surface in terms of M, R, and physical constants. (5 points)

ה. **Use the graph** to calculate the radius R of the imaginary planet. ($4\frac{1}{3}$ points)

Good Luck!

בהצלחה!