State of Israel
Ministry of Education
Type of exam: *Bagrut*
Exam date: Summer 2019
Exam number: 036361
Attachment: Formulas and data for 5-point Physics
English translation (3)

Physics
Mechanics

Instructions for examinees

א. Duration of the exam: Two hours.

ב. Exam structure and breakdown of points:
This exam has six questions. Answer three of them 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 calculator
(2) The physics formulas and 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 they appear in the answer booklet.)
(2) When solving 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 the meaning of that symbol in words. Before you perform your calculations, insert the appropriate values into the formulas.
Write your final answer in the appropriate units. If you do not write out the formula or do not insert the values or do not write the units, points may be subtracted from your score.
(3) When asked to express a magnitude using data from the question, write a mathematical expression that includes some or all of the data given to you in the question.
If necessary, you may also use basic constants, such as the free-fall acceleration g or the elementary charge e.
(4) In your calculations, use the value 10 m/s^2 for the magnitude of free-fall acceleration.
(5) Write your answers in pen. Writing in pencil or erasing with White-Out will preclude any possibility of appealing your score. Use pencil for sketches only.

Write only in the answer booklet. Write "טיוטה" at the top of each draft page. Writing drafts on pages outside the answer booklet may lead to the disqualification of your exam.

Good Luck!

מדינת ישראל
משרד החינוך
סוג הבחינה: בגרות
מועד הבחינה: קיץ תשע"ט, 2019
מספר השאלון: 036361
נספח: נוסחאות ונתונים בפיזיקה ברמה של 5 יח"ל
תרגום לאנגלית (3)

פיזיקה
מכניקה

הוראות לנבחן

א. משך הבחינה: שעתיים.

ב. מבנה השאלון ומפתח ההערכה:
בשאלון זה שש 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 מן הציון.
(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 החופשית.
(5) כתוב את תשובותיך בעט.
כתיבה בעיפרון או מחיקה בטיפקס לא יאפשרו ערעור.
מותר להשתמש בעיפרון לסרטוטים בלבד.

כתוב במחברת הבחינה בלבד. רשום "טיוטה" בראש כל עמוד המשמש טיוטה.
כתיבת טיוטה בדפים שאינם במחברת הבחינה עלולה לגרום לפסילת הבחינה.

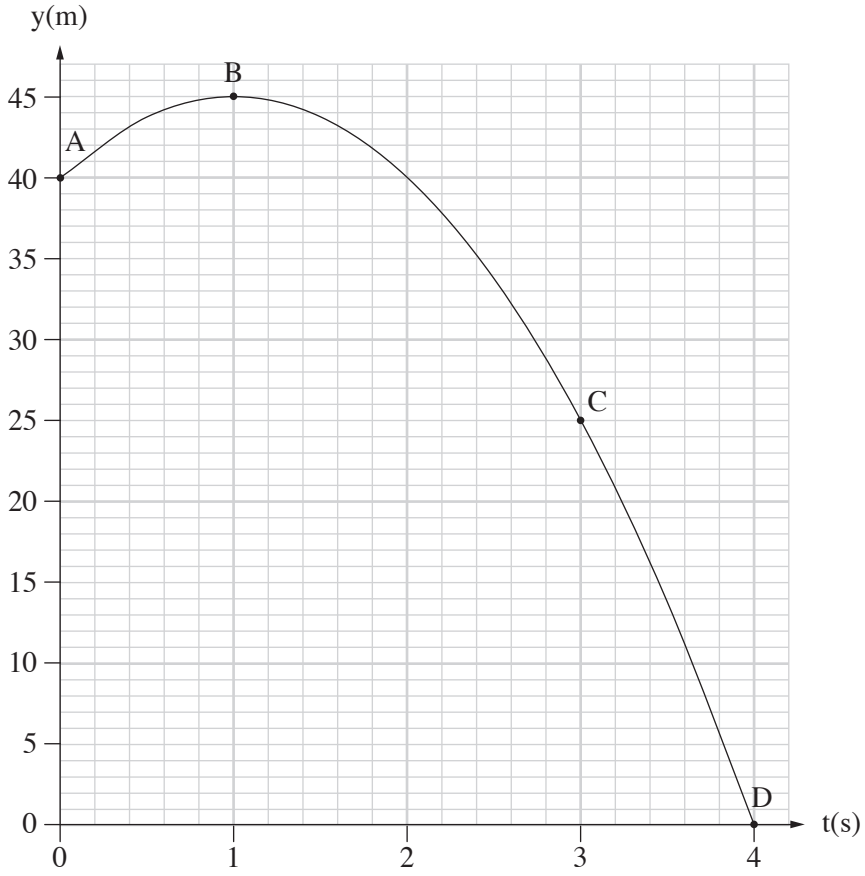
בהצלחה!

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. A man stood on the roof of a building and threw a ball in an upward vertical direction. The graph below shows the vertical position of the ball as a function of time from the moment the ball was thrown until just before it hit the ground. Points A, B, C, and D are marked on the graph.



The resistance of the air is negligible.

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

/Continued on page 3/

א. Calculate the magnitude of the initial velocity at which the ball was thrown. (6 points)

ב. **(1)** Determine whether the **magnitude of the instantaneous velocity** of the ball at Point C was less than, greater than, or equal to the magnitude of its instantaneous velocity at Point A. Explain your answer.

(2) Determine whether the **acceleration** of the ball at Point B was the same as its acceleration at Point A. Explain your answer. In your answer, consider the magnitude and the direction of the acceleration.

(8 points)

ג. Calculate the average velocity (magnitude and direction) of the ball during its motion, from the moment it was thrown until just before it hit the ground. (6 points)

ד. In your answer booklet, sketch a graph of the velocity of the ball as a function of time during its motion, from the moment it was thrown until just before it hit the ground. Mark on your graph the points representing the velocity of the ball at Points A, B, C, and D, using the letters a, b, c, and d, respectively. (8 points)

The man threw the ball a second time from the same place and with the same initial velocity (magnitude and direction). At the moment that the ball passed through Point C, a momentary horizontal force was exerted on it.

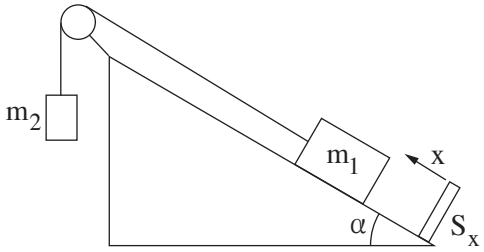
ה. Determine whether the graph y(t) given in the question will change due to this force. Explain your answer. ($5\frac{1}{3}$ points)

/Continued on page 4/

2. Students investigated motion in an experiment on a two-body system: a body with a mass of $m_1 = 0.5kg$ and a body with a mass of m_2.

Body m_1 is held at rest on a <u>smooth</u> inclined plane, and tied to body m_2 by a string that runs over a frictionless pulley (see diagram). The inclined plane is tilted at an angle of $\alpha = 30^o$ to the horizontal. A motion sensor S_x is located at the base of the slope, perpendicular to the inclined plane and connected to a computer. We define the positive direction for the motion of body m_2 as downward motion, and we define the positive direction for the motion of body m_1 as motion up the slope of the inclined plane.

Assume that air resistance, the pulley's mass, and the string's mass are negligible.



At time $t = 0$, they activated the sensor and released body m_1. The body m_1 began to move up the plane. The following table of values appeared on the computer screen. The table presents the velocity of body m_1 as a function of time.

t(s)	0.1	0.2	0.3	0.4	0.5	0.6
$\mathbf{v}\left(\frac{m}{s}\right)$	0.45	0.70	1.15	1.50	1.95	2.25

Assume that body m_1 does not reach the pulley and that body m_2 does not reach the floor.

א. Using the given table, sketch a graph of the velocity of body m_1 as a function of time. (8 points)

ב. Calculate the slope of the graph and explain its physical meaning. (5 points)

ג. Write the force equations of <u>each</u> of the two bodies. (6 points)

ד. Calculate the tension [מתיחות] in the string throughout the motion. (5 points)

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

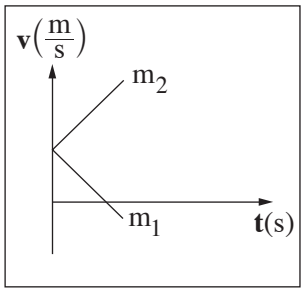
/Continued on page 5/

One second after measurement began, the string broke.

ה. Calculate $\frac{a_1}{a_2}$, the ratio between the accelerations of bodies m_1 and m_2, after the string broke. (5 points)

ו. Determine which of the following graphs 1-4 correctly describes the velocities of the bodies as a function of time from the moment the string broke.

Explain your answer. ($4\frac{1}{3}$ points)



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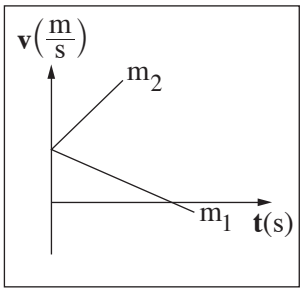

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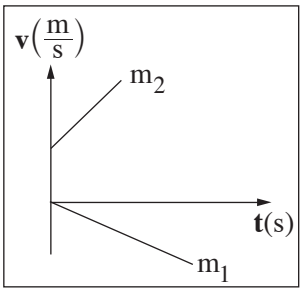

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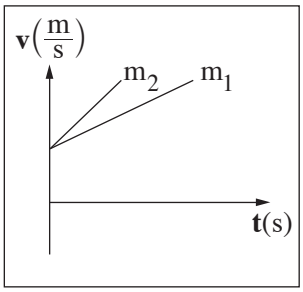

1

/Continued on page 6/

3. Figure 1 shows an attraction in an amusement park. Its structure is cylindrical, with a radius of $r = 3\text{m}$, and it can rotate around its vertical axis OP. A man whose mass is $m = 70\,\text{kg}$ is standing on the floor inside the cylinder, with his back pressed to the inside wall of the cylinder. The coefficient of static friction between the man and the wall is $\mu_s = 0.6$.

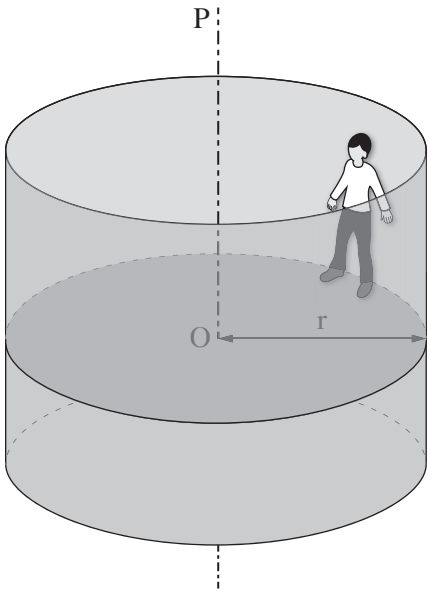

Figure 1

The cylinder begins to rotate around the axis OP, at a continuously increasing velocity. When the rotational velocity of the cylinder reaches a certain value, the floor of the cylinder is lowered, but the position of the man relative to the cylinder wall does not change (see Figure 2 on the next page).

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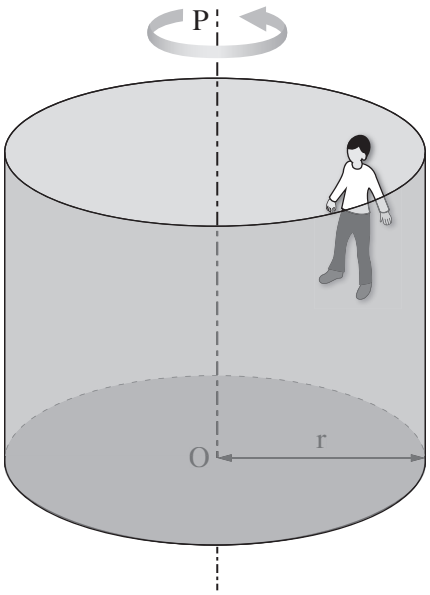


Figure 2

The following items relate to the situation shown in Figure 2, in which there is no contact between the man's feet and the floor of the cylinder.

א. In your answer booklet, sketch a diagram of the forces acting on the man.
Label each force. (6 points)

ב. Write the force equations for the forces acting on the man in each of the two axes, the vertical axis and the horizontal (radial) axis. (7 points)

ג. Calculate the magnitude of the minimum angular velocity required to keep the man pressed to the cylinder wall, without his vertical position changing. (8 points)

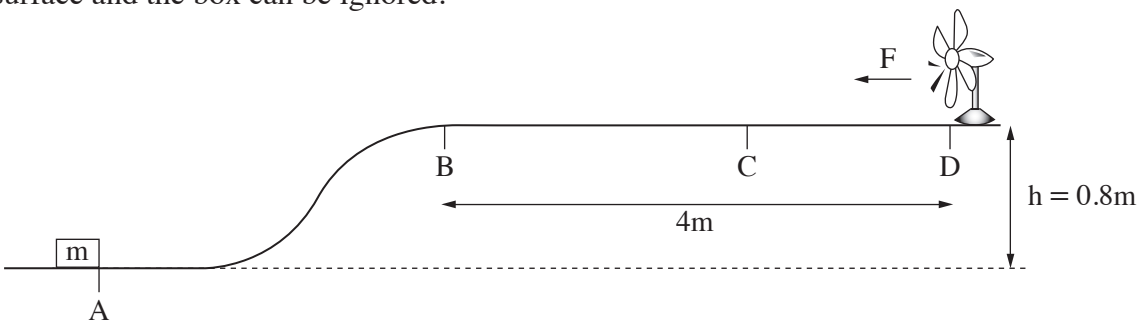
ד. Determine whether your answer to Item ג would change if the mass of the man were 90kg. Assume that the coefficient of friction does not change.
Explain your answer. (6 points)

The cylinder is rotated at an angular velocity $\omega = 2.6\frac{1}{s}$, at which the position of the man does not change relative to the cylinder wall.

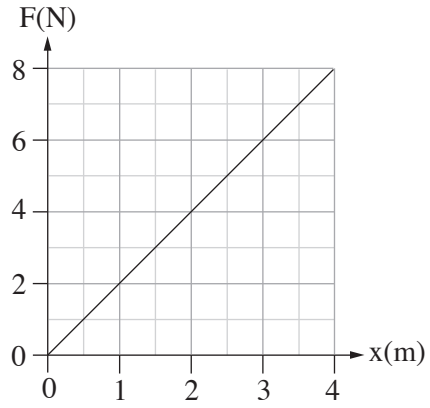
ה. Calculate the magnitude of the static frictional force exerted at this velocity on a man whose mass is $m = 90kg$. ($6\frac{1}{3}$ points)

/Continued on page 8/

4. To investigate the subject of mechanical energy, a student built a system consisting of a box of mass m = 2kg, a surface AD, and a fan (see figure). Segment BD of the surface is a horizontal plane of length 4m, and its height above the ground is h = 0.8m. The friction between the surface and the box can be ignored.



The student placed the box at Point A and the fan at Point D. The fan set the air in motion and generated a horizontal wind. Assume that the magnitude of the force F that the wind exerted on the box is linearly dependent on the distance x of the box to the right of Point B, as shown in the graph below. The magnitude of the force is greatest (maximal) at Point D and zero at Point B. The wind has no effect to the left of Point B.



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In this question, consider only the effect of the air from the fan, and ignore all other effects of the air.

א. Calculate the smallest (minimum) magnitude of velocity it is necessary to impart to the box located at Point A so that it will move up the surface and reach Point B. (6 points)

The student imparted to the box at Point A an initial velocity $v_0 = 5\frac{m}{s}$ in the rightward direction. When the box reached Point B, the force F(x) began to affect it.
At Point C, the box stopped momentarily.

ב. Calculate the work of the force F(x) from Point B to Point C. (7 points)

ג. Calculate the distance of Point C from Point B. (8 points)

After the momentary stop at Point C, the box moved back in the direction of Point B.

ד. Describe in words the motion of the box from Point C to Point B. In your answer, address the following attributes: uniform or accelerated motion, constant or variable acceleration, increasing or decreasing **magnitude** of velocity. (6 points)

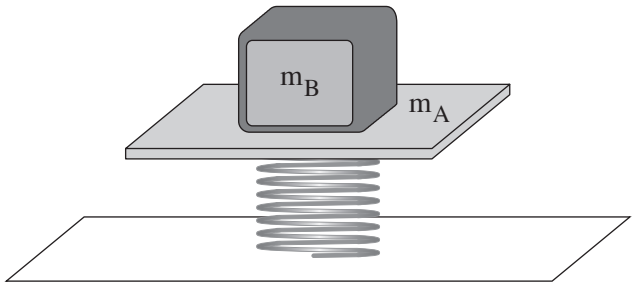
ה. Determine the magnitude of the velocity of the box when it reaches Point A again. Explain your answer.
In your answer, address also the non-conservative forces [כוחות לא משמרים] present in the system. ($6\frac{1}{3}$ points)

/Continued on page 10/

Harmonic Motion

5. The following diagram shows a system for measuring body masses (without using a spring balance). The system is composed of a a flat surface A of mass m_A resting on a spring whose constant is k. The mass of the spring is negligible.

We place a body B, whose mass m_B we wish to measure, on surface A, and attach them to each other so that surface A and body B will remain attached throughout the experiment.

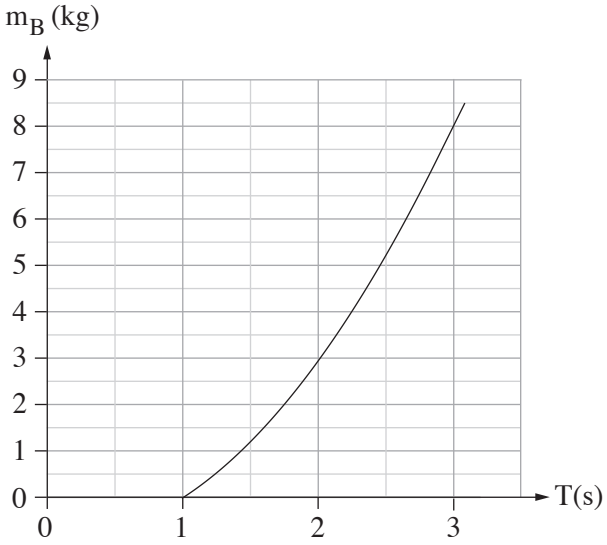


We disturb the system from a state of equilibrium so that it will undergo simple harmonic motion (SHM). We measure the time of 10 periods and calculate the average period T.

א. Explain the advantage of measuring the time of 10 periods versus measuring the time of a single period. ($5\frac{1}{3}$ points)

ב. Express the body mass m_B as a function of the average period T. (6 points)

The body mass m_B can be determined from the average period T by using the following graph.



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

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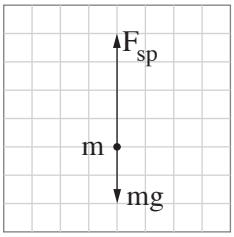
ג. The graph on the previous page does not show periods smaller than 1.0s .
Explain why periods smaller than 1.0s cannot be measured in this system. (7 points)

ד. Given: The mass of the surface is $m_A = 1kg$. Calculate the spring constant k. (7 points)

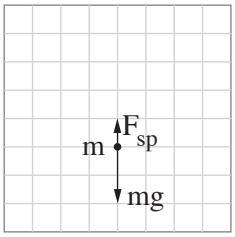
We denote: $m = m_A + m_B$

F_{sp} — the force that the spring exerts on the mass m.

Shown below are four diagrams of the forces acting on the mass m at different points during its motion.



(4)



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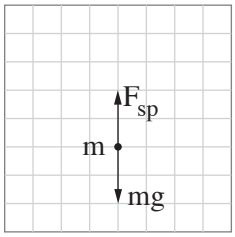
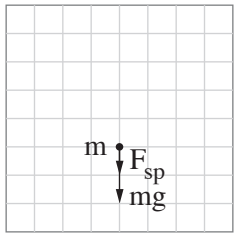


(2)



(1)

ה. For <u>each</u> of the diagrams (1)-(4), determine whether the mass m is located at, above, or below the equilibrium point.
Copy the following table to your **answer booklet** and mark your answers in the table. (8 points)

Diagram / Mass Position	**(1)**	**(2)**	**(3)**	**(4)**
Above equilibrium point				
At equilibrium point				
Below equilibrium point				

/Continued on page 12/

Gravitation

6. In July 1969, on the Apollo 11 mission, a spacecraft was sent to the moon. During its journey, the spacecraft was put into a circular "parking orbit" around the earth, in which the spacecraft traveled like a satellite (see Figure 1). From the parking orbit, the spacecraft continued to the moon. During this mission, humans landed on the moon for the first time.

Assume that the mass of the spacecraft is m and that the height of the parking orbit above the earth is h = 190km.

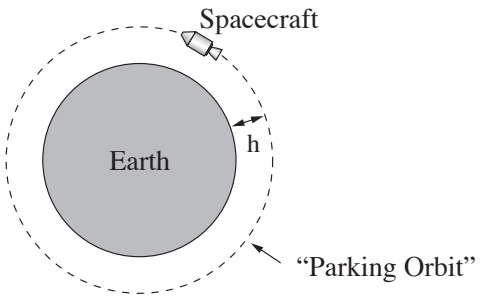


Figure 1

In Items א-ג, assume that only the earth affects the spacecraft.

א. Using the constants given in the formula sheet, calculate the magnitude of the velocity of the spacecraft in the parking orbit.

(7 points)

ב. A student claims that according to Newton's First Law, in the parking orbit, the spacecraft is in a state of inertia, because it is moving at a velocity with a constant magnitude. Determine whether the student is correct and explain your answer.

(7 points)

ג. If the spacecraft traveling in the parking orbit had a larger mass:

(1) Determine whether the magnitude of the velocity of the spacecraft would be larger, smaller, or the same. Explain your answer.

(2) Determine whether the total mechanical energy of the spacecraft would be larger, smaller, or the same. Explain your answer. (Note the sign of the energy.)

(8 points)

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

/Continued on page 13/

Assume that the spacecraft continued from the parking orbit to the orbit around the moon along a straight line connecting the center of the earth to the center of the moon.

Point D is located on this line (see Figure 2).

Given: M_E — the mass of the earth, M_M — the mass of the moon.

r_E — the distance from the center of the earth to Point D.

r_M — the distance from the center of the moon to Point D.

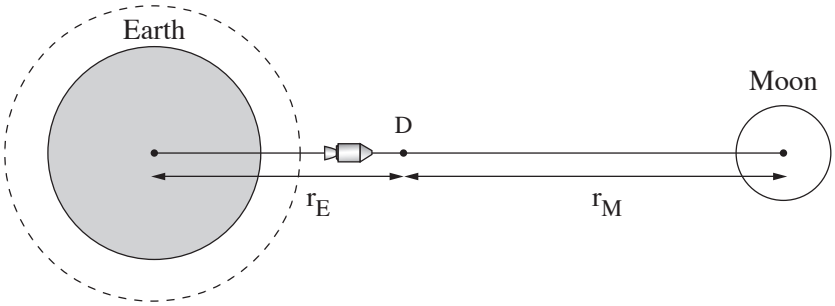
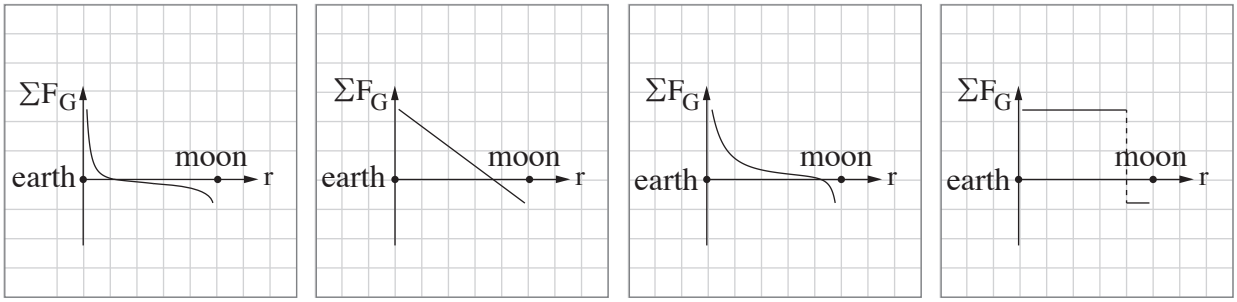


Figure 2

In Items ד-ה, assume that only the earth and the moon affect the spacecraft.

ד. Express the net gravitational force [שקול כוחות הכבידה] acting on the spacecraft, ΣF_G, at Point D, in terms of r_M, r_E, M_M, M_E, m, G. (7 points)

Shown below are four graphs that approximately represent the net gravitational force, ΣF_G, as a function of the distance of the spacecraft from the center of the earth, r.



4 **3** **2** **1**

ה. Determine which of the graphs 1-4 correctly describes the net gravitational force, ΣF_G, acting on the spacecraft during its travel from the parking orbit to the moon. ($4\frac{1}{3}$ points)

Good Luck!

בהצלחה!