State of Israel
Ministry of Education
Type of Examination:
Highschool matriculation
Date of the Exam: Summer 2014
Examination Code: 917554
Appendix: Data and physical expressions for 5 units

Physics – Research Laboratory

For students of 5 units of study
Instructions

a. Duration of the exam: two hours

b. Structure of the exam and evaluation key: This exam consists of sixteen questions. You are to answer **all** questions 1–15 and **one** of the questions 16–17.

Total: 100 points.

c. Help material:

1. A calculator and a ruler.

d. Special instructions:

1. Pencil may be used for drawing/ sketching only.
2. Pages 13–14 may be used as draft paper.
3. This questionnaire is to be used as the test booklet and attached to the booklet cover.
4. The examinee sticker must be adhered to the designated place on the front page and on the booklet cover.
5. The examinee sticker must be adhered to any page produced by the computer printer.

Note to test administrator: Write your comments on page 16.

This questionnaire consists of 16 questions and an appendix with formulas.

Good Luck!

Continuation on the next page ▶

מדינת ישראל
משרד החינוך
סוג הבחינה: בגרות לבתי־ספר על־יסודיים
מועד הבחינה: קיץ תשע"ד, 2014
סמל השאלון: 917554
נספח: נתונים ונוסחאות בפיזיקה לחמש יח"ל
תרגום לאנגלית (3)

פיזיקה – מעבדת חקר

לנבחנים ברמת חמש יחידות לימוד
הוראות לנבחן

א. משך הבחינה: שעתיים.

ב. מבנה השאלון ומפתח הערכה:
בשאלון זה שש־עשרה שאלות. עליך לענות על **כל** השאלות 1–15, ועל שאלה **אחת** מבין השאלות 16–17.
סה"כ – 100 נקודות.

ג. חומר עזר מותר לשימוש: מחשבון וסרגל.

ד. הוראות מיוחדות:

1. מותר להשתמש בעיפרון לסרטוטים בלבד.
2. העמודים 13–14 משמשים כטיוטה.
3. שאלון זה משמש כמחברת בחינה ויש להצמיד אותו לעטיפת המחברת.
4. הדבק מדבקת נבחן במקום המיועד לכך בדף השער ובעטיפת המחברת.
5. הקפד להדביק מדבקת נבחן על כל תדפיס מחשב שהפקת, וצרף אותו לשאלון.

הערה לבוחן: רשום את הערותיך בעמוד 16.

בשאלון זה 16 עמודים ונוסחאון.

בהצלחה!

13:27,19/03/2014

המשך מעבר לדף ◀

Exploring the oscillations of a pendulum made of paper clips

Theoretical background

A mathematical pendulum consists of a point mass, m, which is suspended from a cord of length L and with negligible mass. When the point mass is displaced from its equilibrium position, it oscillates about it. These oscillations are called harmonic oscillations. The time required for the mass to return to its original location, at the same velocity (amplitude and direction), is called its period.

It can be assumed that when the mass is displaced from its equilibrium position by small angles (less than 20º), the period is:

$$T = 2\pi\sqrt{\frac{L}{g}}$$

When the mass is not a point mass, the pendulum is called a physical pendulum.

A physical pendulum consists of a body which is not a point mass, and which is suspended from a pivot.

You will conduct the following experiment using a physical pendulum that is displaced from its equilibrium position by small angles and obeys the following relationship:

$$T = 2\pi\sqrt{\frac{2L}{3g}}$$

L is the overall length of the physical pendulum.

g is the acceleration of gravity.

In this experiment you will explore the period of the physical pendulum oscillations.

The physical pendulum in the experiment is a chain of paper clips.

Equipment

1. a mounting board, 50 cm long
2. a small clamp
3. a large bench clamp (suggested to use it in order to fasten the mounting board to the table).
4. a ruler, 1 meter long
5. a stopwatch
6. 40 metal paper clips, each about 50 mm long
7. A solid wire triangle for angular deflection setting.
8. a wooden rod, approximately 15 cm long, with a hook on one end
9. a piece of a thread , approximately 60 cm long

Continues on page 3 ▶

Part A: Exploration of the time period of the pendulum oscillations (58 points)

(4 pts.) 1. Setting up the apparatus

- Place the mounting board on the table (you may fasten it to the table if you have a bench clamp).
- Attach the wooden rod to the mounting board using the small clamp, so that the rod is horizontal.
- Place the triangular wire on the wooden rod.
- Assemble a 24 paper clips chain. Attach the clips one to another by their edges (and not by their internal parts).
- Hang the chain by one of its ends on the hook of the wooden rod. Make sure that the chain does not touch the floor.

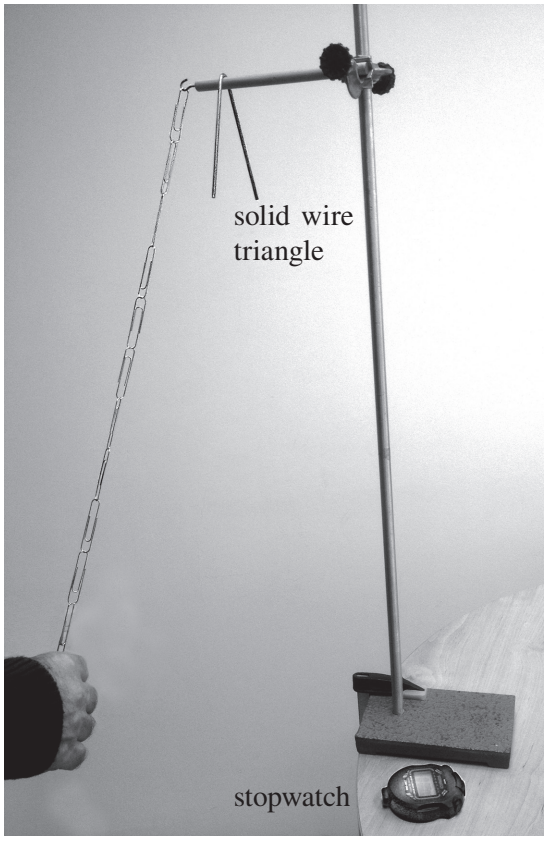


Figure 1: a photograph of the paper clip pendulum

Continues on page 4

(18 pts.) 2. Conducting the experiment

– Displace the chain by about 20º (use the triangular wire in the kit). Make sure you release the chain in a way that keeps the oscillation plane as steady as possible. Practice releasing the chain several times without taking a measurement. Make sure the chain does not hit any obstacle as it moves.

– Measure the chain length, L, and record the value in the appropriate place in the table.

Measurement number	**Number of paper clips**	**Length of pendulum L [ ]**	**10 T I [ ]**	**10 T II [ ]**	**10 T III [ ]**	**10 T Average [ ]**	**T [ ]**	
1	24							
2	20							
3	16							
4	12							
5	8							
6	4							
7	double chain							

– Displace the chain by about 20º. Release it and record the duration of ten periods (10T). Perform the measurement three times and record the values in appropriate places in the table.

– Remove four paper clips from the chain each time and repeat the previous measurements (10T, L) until the chain consists of only four paper clips. Record the values in the appropriate places in the table.

– Assemble a chain from 24 paper clips once again. Attach both ends of the chain to the hook to form a double chain of 12 paper clips. Repeat the measurements of L and 10T and record the values in the appropriate places in the table.

Continues on page 5 ▶

(4 pts.) **3.** (3 pts.) a. For each chain length, calculate the average of the time measurements you took. Write the calculation results in the "10T average" column.

(1 pts.) b. Calculate the values of T and write them in the "T" column.

(2 pts.) **4.** Indicate the appropriate units of measurement at the designated place in the heading of each column of the table.

(5 pts.) **5.** (3 pts.) a. Did you expect to be a difference between the T values obtained at measurement 4 and the T values obtained at measurement 7? Explain your answer.

(2 pts.) b. Do you consider the difference between the two measurements to be significant? Explain how you determined it.

(3 pts.) **6.** There are two ways to start the time measurement:

– from an extreme point of the oscillation

– from the lowest point of the oscillation

Specify the advantage and disadvantage of **one** of these ways.

Continues on page 6

(3 pts.) **7.** Explain why the relative error in determining the period of the chain is smaller measuring ten periods, rather than measuring one period.

(8 pts.) **8.** (4 pts.) a. Considering the theoretical background, determine which of the following variables has a linear relation to the length (L) of the pendulum.

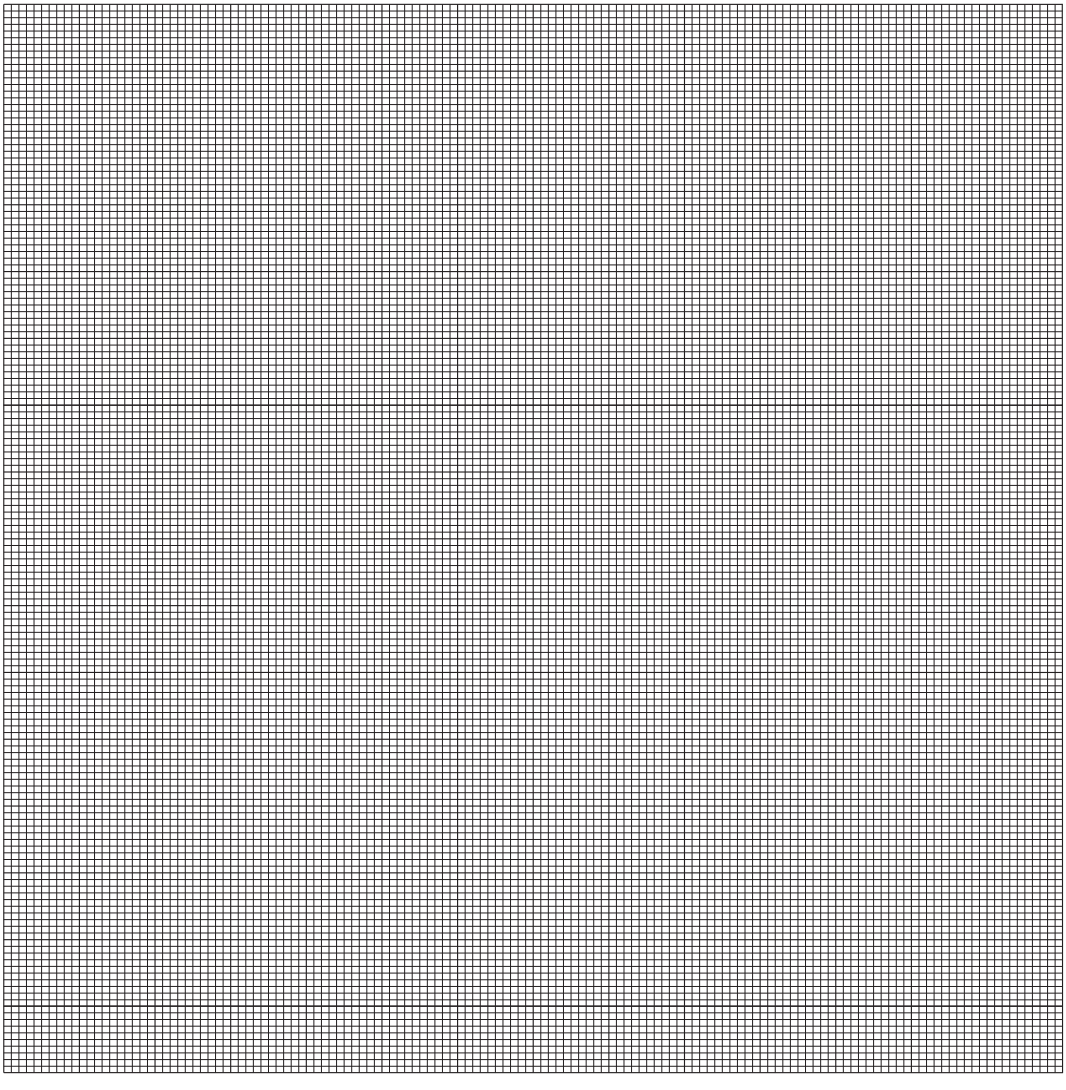
- T
- T^2
- $\sqrt{T}$
- $\frac{1}{T}$

Explain your answer.

(2 pts.) b. Based on your answer in section (a), fill the empty column in the table on page 4. At the heading of the column, write the variable you selected in section (a) and its units.

Continues on page 7

(8 pts.) **9.** On the millimeter paper below*, draw a scatter diagram describing the linear relationship between the variables which you selected in question 8. Use the values for the first 6 measurements in the table.



* On page 13 you will find additional millimeter paper that you may use if necessary. You may also use electronic worksheet according to the examiner instructions.
If you use electronic worksheets, stick your examinee sticker also to the computer printout, and add it to the questionnaire.

Continues on page 8 ▶

(3 pts.) **10.** Onto the scatter diagram, add a linear trend line (the straight line which best fits the scatter diagram).

Questions about the experiment (32 pts.)

(10 pts.) **11.** (3 pts.) a. Calculate the slope of the trend line which you drew. Specify your calculations.

(3 pts.) b. What is the theoretical value which you would expect to get for the slope of the trend line? Explain your answer.

(2 pts.) c. Calculate the relative error.

(2 pts.) d. Explain the meaning of the intercepts of the trend line with each of the axes in the graph you drew.

(8 pts.) **12.** (3 pts.) a. Does the friction created between the chain and the air has a decisive influence on the time period measurements you took? Explain your answer.

(3 pts.) b. Does the friction created between the chain and the hook has a decisive l influence on the time period measurements you took? Explain your answer.

Continues on page 9 ▶

(2 pts.) c. The person performing the measurements influences their level of precision. What are the error-factors resulting from this influence?

(6 pts.) **13.** (3 pts.) a. Process the results of the experiment you performed, to determine how long the time period of a 45 cm long chain is. Describe how you reached your answer.

(3 pts.) b. Is it possible to directly measure the period of a 45 cm long paper clip chain using the apparatus you have? Explain your answer.

(4 pts.) **14.** What do you estimate would be the ratio measured between an 11 paper clips time period and a 22 paper time period? Explain your answer.

(4 pts.) **15.** Using the thread, construct a mathematical pendulum consisting of a weight made of 12 paper clips suspended from its end. Hang the other end of the pendulum on a hook so that the overall length of the pendulum is identical to the length of the pendulum you built using 12 paper clips for measurement 4.

(2 pts.) a. What is the period of the mathematical pendulum?

(2 pts.) b. Both pendula, the mathematical pendulum and the paper clip pendulum, have approximately the same mass and same length, but they have different periods.
Explain what causes this difference.

Continues on page 10 ▶

Part B: Questions about the compulsory experiments (10 points)

Answer one of questions 16-17 (10 points for each question).

(10 pts.) 16. This question relates to the experiment "EMF and terminal voltage".

(2 pts.) a. Is the variable resistor used in the experiment connected via a rheostatic connection or a potentiometric connection?

Draw a diagram of the electric circuit used in the experiment.

(3 pts.) b. Draw a qualitative graph describing the inter-dependence of the magnitudes measured in the experiment.

Continues on page 11

(3 pts.) c. Explain how the internal resistance of the battery is determined in the experiment.

(2 pts.) d. What is the purpose of using the variable resistor in the experiment?

(10 pts.) 17. This question relates to the experiment "Newton's second law in a two-body system", described in the following illustration:

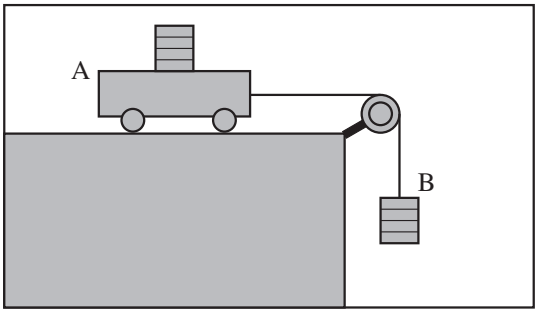


Illustration for question 17

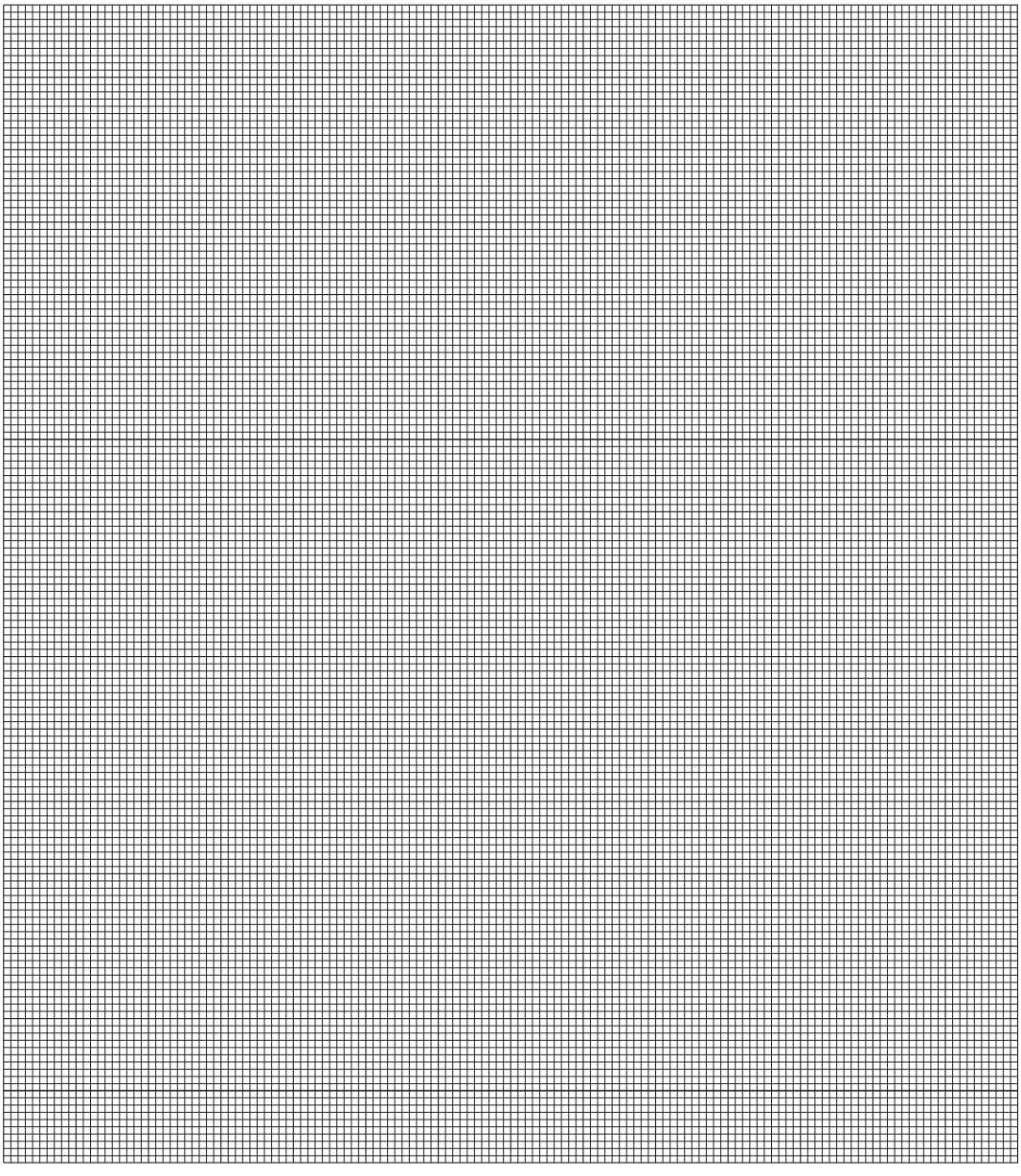
(3 pts.) a. Does the transferring of weights from Body A to Body B take place in the part of the experiment which checks the dependence of the acceleration, a, on the resultant force, ΣF, or in the part of the experiment which checks the dependence of a on the overall mass of the system? Explain your answer.

Continues on page 12

(4 pts.) b. Draw a qualitative graph describing the relationship between the magnitudes specified in your answer to section (a).

(3 pts.) c. Describe the physical principle of the measuring device which you used in the experiment.

Continues on page 13



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Continues on page 16

Examiner Obesrvations

Good Luck!