משרד החינוך

המִנהל הפדגוגי — אגף בכיר בחינות

מחברת בחינה

לנבחנים ולנבחנות שלום,

נא לקרוא את ההוראות בעמוד זה ולמלא אותן בדייקנות. אי־מילוי ההוראות עלול לגרום לתקלות ואף להביא לידי פסילת הבחינה.

הבחינה נועדה לבדוק הישגים אישיים, ולכן יש לעבוד עבודה עצמית בלבד. בזמן הבחינה אין להיעזר בזולת ואין לתת או לקבל חומר בכתב או בעל פה.

אין להכניס לחדר הבחינה חומר עזר — ספרים, מחברות, רשימות — פרט ל"חומר עזר מותר בשימוש" המפורט בגוף השאלון או בהוראות מוקדמות של המשרד. כמו כן **אין להכניס לחדר הבחינה טלפונים או מחשבים ניידים**. שימוש בחומר עזר שאינו מותר יוביל לפסילת הבחינה.

כל חומר עזר שאינו מותר בשימוש, יש למסור למשגיח לפני תחילת הבחינה.

לאחר סיום כתיבת הבחינה יש למסור את המחברת למשגיח ולעזוב בשקט את חדר הבחינה.

יש להקפיד על טוהר הבחינות!

הוראות לבחינה

1. יש לוודא כי במדבקות הנבחן שקיבלת מודפסים הפרטים האישיים שלך, ובמדבקות השאלון שקיבלת מודפסים פרטי השאלון המיועד לך.
2. אם לא קיבלת מדבקה, יש למלא בכתב יד את הפרטים במקום המיועד למדבקת הנבחן.
3. אסור לכתוב בשולי המחברת (החלק המקווקו) משום שחלק זה לא ייסרק.
4. לטיוטה ישמשו אך ורק דפי מחברת הבחינה שיועדו לכך.
5. **אין לתלוש או להוסיף דפים**. מחברת שתוגש לא שלמה תעורר חשד לאי־קיום טוהר הבחינות.
6. אין לכתוב שם בתוך המחברת, משום שהבחינה נבדקת בעילום שם.
7. אין להוסיף או לשנות שום פרט במדבקות, כדי למנוע עיכוב בזיהוי המחברת וברישום הציונים.

ב ה צ ל ח ה !

מדבקות לנבחן
ملصقة ممتحن

מועד 18 — 21
موعد

סמל בי"ס 32 — **מס' תעודת זהות** 31 — 23 37
رقم المدرسة — رقم الهوية

יש להדביק כאן ↑ מדבקת נבחן (ללא שם)
يجب هنا ↑ إلصاق ملصقة ممتحَن (بدون اسم)

סמל שאלון 12 — 17
رقم النموذج

שם השאלון
اسم النموذج

יש להדביק כאן ↑ מדבקת שאלון
يجب هنا ↑ إلصاق ملصقة نموذج امتحان

* הוראות בשפה הערבית מעבר לדף
* التّعليمات باللّغة العربيّة على ظهر الصّفحة

יש לסמן במשבצת ☐ אם ניתן שאלון נוסף
يجب الإشارة في المربّع ☐ إذا أُعطي نموذج امتحان إضافيّ

وزارة التّربية والتّعليم

الإدارة التّربويّة القسم الكبير للامتحانات

دفتر امتحان

تحيّة للممتحَنين وللممتحَنات!

الرّجاء قراءة التّعليمات في هذه الصّفحة والعمل وفقًا لها بدقّة. عدم تنفيذ التّعليمات قد يؤدّي إلى عوائق مختلفة وحتّى إلى إلغاء الامتحان. أُعدّ الامتحان لفحص تحصيلاتك الشّخصيّة، لذلك يجب العمل بشكل ذاتيّ فقط. أثناء الامتحان، لا يُسمح طلب المساعدة من الغير ويُمنع إعطاء أو أخذ موادّ مكتوبة أو شفهيّة.

لا يُسمح إدخال موادّ مساعدة – كتب، دفاتر، قوائم – إلى غرفة الامتحان، باستثناء "موادّ مساعدة يُسمح استعمالها" المفصّلة في نموذج الامتحان أو في تعليمات مسبقة من الوزارة. كما **لا يُسمح إدخال هواتف أو حواسيب محمولة إلى غرفة الامتحان**. استعمال موادّ مساعدة غير مسموح بها يؤدّي إلى إلغاء الامتحان.

يجب تسليم كلّ مادّة مساعدة لا يُسمح استعمالها للمراقب قبل بدء الامتحان.

بعد الانتهاء من كتابة الامتحان، يجب تسليم الدّفتر للمراقب، ومغادرة غرفة الامتحان بهدوء.

يجب التّقيّد بنزاهة الامتحانات !

تعليمات للامتحان

1. يجب التّأكّد بأنّ تفاصيلك الشّخصيّة مطبوعة على ملصَقات الممتحَن الّتي حصلت عليها، وبأنّ تفاصيل نموذج الامتحان المعدّ لك مطبوعة على ملصَقات نموذج الامتحان الّتي حصلت عليها.
2. في حال عدم حصولك على ملصَقة، يجب ملء التّفاصيل في المكان المعدّ لملصَقة الممتحَن، بخطّ يد.
3. لا يُسمح الكتابة في هوامش الدّفتر (في المنطقة المخطّطة)، لأنّه لن يتمّ مسح ضوئيّ لهذه المنطقة.
4. للمسوّدة تُستعمَل أوراق دفتر الامتحان المعدّة لذلك فقط.
5. **يُمنع نزع أو إضافة أوراق**. الدّفتر الّذي يُسلَّم ناقصًا يُثير الشّكّ بعدم الالتزام بنزاهة الامتحانات.
6. لا يُسمح كتابة الاسم داخل الدّفتر، لأنّ الامتحان يُفحص بدون ذكر اسم.
7. لا يُسمح إضافة أو تغيير أيّة تفاصيل في الملصَقات، وذلك لمنع عوائق في تشخيص الدّفتر وفي تسجيل العلامات.

نتمنّى لكم النّجاح!

State of Israel
Ministry of Education
Type of Examination: Highschool matriculation
Exam date: Summer 2019
Exam Code: 036386
Appendix: Physics data and formulas for 5 units

מדינת ישראל
משרד החינוך
סוג הבחינה: בגרות לבתי־ספר על־יסודיים
מועד הבחינה: קיץ תשע"ט, 2019
סמל השאלון: 036386
נספח: נתונים ונוסחאות בפיזיקה לחמש יח"ל
תרגום לאנגלית (3)

Physics – Research Laboratory

פיזיקה – מעבדת חקר

Instructions

a. **Duration of the exam:** two and a half hours.

b. **Questionnaire structure and evaluation key:**
This questionnaire consists of fifteen questions.
You should answer **all** questions 1-13,
and **one** of the questions 14-15.
Total: 100 points.

c. **Allowed materials:** calculator and ruler.

d. **Special instructions:**

1. Write all your answers in specified areas **in the questionnaire**.
2. Write using a **pen only**. Pencil may be used for drawing/sketching only.

e. Page 15 may be used for examiner notes, pages 16-17 may be used for drafts.

You may write **only in the exam booklet**. Write all your **drafts** (outlines, calculations etc.) on pages 16-17.
Writing drafts on any other piece of paper other than the exam booklet may disqualify your exam!

This questionnaire consists of 17 pages and formula pages.

Good Luck!

Continue to next page ▶

הוראות לנבחן

א. **משך הבחינה:** שעתיים וחצי.

ב. **מבנה השאלון ומפתח ההערכה:**
בשאלון זה חמש־עשרה שאלות.
עליך לענות על **כל** השאלות 1–13,
ועל שאלה **אחת** מבין השאלות 14–15.
סה"כ – 100 נקודות.

ג. **חומר עזר מותר לשימוש:** מחשבון וסרגל.

ד. **הוראות מיוחדות:**

1. רשום את כל תשובותיך **בגוף השאלון**, במקומות המיועדים לכך.
2. כתוב **בעט בלבד**. מותר להשתמש בעיפרון לסרטוטים בלבד.

ה. עמוד 15 משמש להערות הבוחן, ועמודים 16–17 משמשים לטיוטה.

כתוב **במחברת הבחינה בלבד**, בעמוד 16–17, כל מה שברצונך לכתוב **כטיוטה** (ראשי פרקים, חישובים וכדומה).
רישום טיוטות כלשהן על דפים שמחוץ למחברת הבחינה עלול לגרום לפסילת הבחינה!

בשאלון זה 17 עמודים ונוסחאון.

בהצלחה!

ההנחיות בשאלון זה מנוסחות בלשון זכר, אך מכוונות לנבחנות והן לנבחנים.

המשך מעבר לדף ◀

Part A: Studying Springs Connected In Parallel (90 points)

Please answer all questions 1-13.

Section 1 – Finding the force constant of a spring in a static method by connecting springs in parallel

Here we will calculate the force constant of **one** spring, by measuring the increase in length of n identical springs connected in parallel.

Theoretical background

Hooke's Law:

When you extend or compress a spring in its elastic limit, the force on the spring scales linearly to the distance it was compressed or extended.

The size of the force is: $\mathbf{F = k \cdot \Delta L}$

When:

ΔL – the distance of extending (or compressing) the spring (in relation to its loose state) in meters (m);

k – The force constant of the spring. When force is measured in Newton units (N) and the extension of the spring is measured in meters (m), the force constant is measured in N/m units.

List of Equipment

1. The experiment kit contains:

- Two vertical panels, 55 cm tall
- One bottom panel, 30 cm long
- One upper panel, 30 cm long – connected to a metal plate with holes

} **Parts of the frame**

- A ring - mass 0.5 gram, with 4 weights on it - each weight's mass is about 16 grams (total weight of the ring and weights is 64.0 grams).
- A metal plate with holes, mass 18.0 grams (bottom plate)
- Six identical springs (one of them for backup if needed)
- A measuring ruler made of cardboard and a metal clip to attach the ruler to the frame

2. A stopwatch, provided to you by the school.

Continue to page 3

Constructing the Experiment System

- Build the frame, as shown in Figure A. For it to be stable, make sure that the horizontal panels (the narrower ones) are inserted to the vertical panels all the way into the slots.
- Take the cardboard ruler and fold its edge according to the mark, as shown in Figure B.
- Place the ruler on the upper panel, so that the numbers appear in front of you, attach it to the upper panel with the metal clip. Connect a spring to the middle hole on the metal plate, as shown in Figure C.

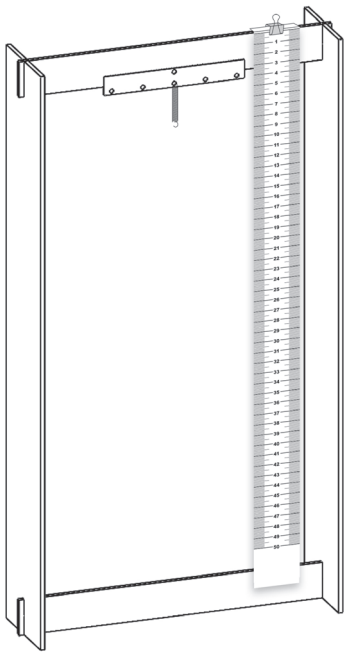


Figure C

Figure B

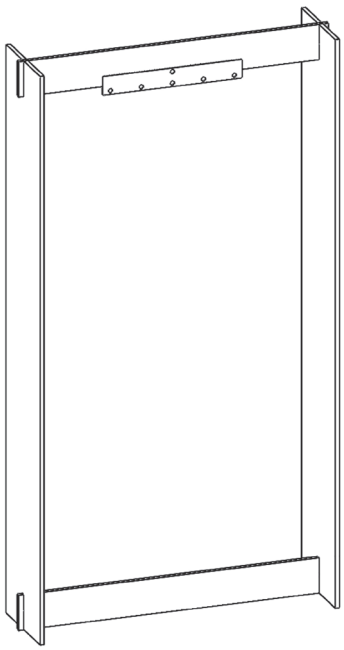


Figure A

<u>Conducting the Experiment</u>

Question 1 (3 points)

With the ruler, measure the length of the spring in its loose state. Write its value

L_0 = _____.

<u>Notice</u>: You should measure the active length of the spring, without the loops on both its ends.

Continue to page 4

Question 2 (15 points)

(3 pts.) **a.** Connect the ring with the 4 weights to the bottom hole of the attached metal plate and hang them on the spring, as shown in Figure D. Measure the length of the spring, L_T, and write it and its extension, ΔL, **in Table 1**.

(2 pts.) **b.** Write the physical units of the length of the spring and its extension in the parentheses (brackets) at the head of each column **in Table 1**.

(10 pts.) **c.** Change the number of springs attached to the bottom metal plate, as shown in Figures E – H: two springs (Figure E), three springs (Figure F), four springs (Figure G), five springs (Figure H). Each time, measure the length of one of the springs, L_T, and write it and its extension, ΔL, **in Table 1**.

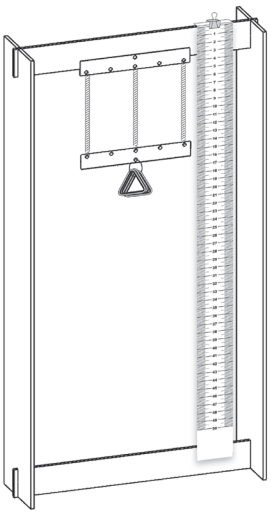


Figure F

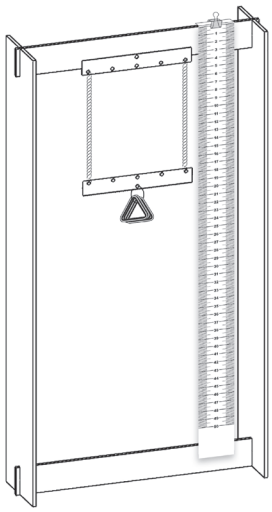


Figure E

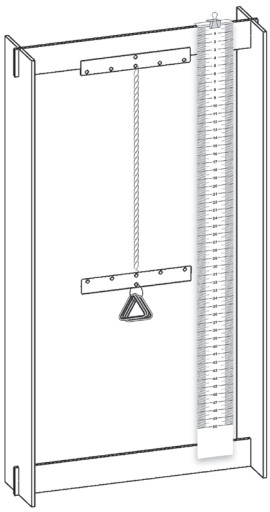


Figure D

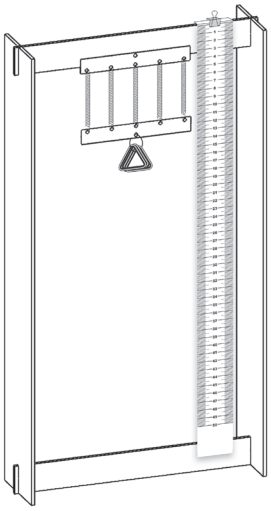


Figure H

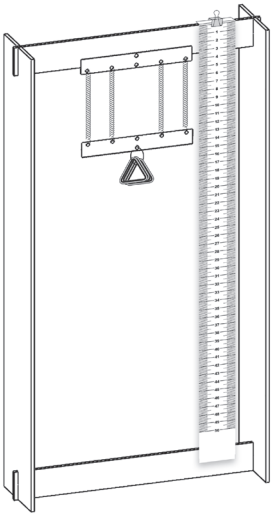


Figure G

Continue to page 5

Notice:

1. You should measure the active length of the spring when it is loose in the point of equilibrium, and when the bottom metal plate is horizontal.
2. Watch that the starting measuring point of the spring length is not at the 0-line on the ruler.
3. If you see a difference between the extension of the system on the right and the extension on the left – make sure to perform all measurements on the same spring.

Table 1

No. of Measurement	**Number of Springs n**	**Length of Spring L_T [ ]**	**Extension of Spring $\Delta L = L_T - L_0$ [ ]**	
1				
2				
3				
4				
5				

Question 3 (6 points)

Draw the diagram of forces that are acting on the system with the four weights and the ring (of which the total mass in kg is m) and the bottom plate (of which the mass in kg is M), when n springs are connected in parallel and the system is at rest.

Prove that the connection between ΔL and n is: $\Delta L = \frac{(m+M)g}{k} \cdot \frac{1}{n}$, when k is the force constant of one spring.

Force Diagram **Proof**

Question 4 (2 points)

Add, in the head of the empty column in **Table 1**, the variable that has a linear connection with ΔL, according to your answer to question 3. Write its values in this column.

Continue to page 6

Question 5 (10 points)

(5 pts.) **a.** On the millimeteric paper (on the next page), draw a scattering diagram which will describe the linear connection between the dependent variable and the independent variable from question 4, according to the results you wrote **in Table 1**.

(5 pts.) **b.** Draw a trend line in the scattering diagram (the straight line that is most suitable to the diagram).

Question 6 (8 points)

(4 pts.) **a.** Calculate the slope of the trend line, and write its physical units.

(4 pts.) **b.** Using the slope of the trend line, find the force constant k of one spring (by the connection you have proved in question 3), and write its physical units. Present your calculations.

Question 7 (3 points)

We will define the **force constant of several springs connected in parallel** as the force constant of one **equivalent** spring, k_T; when we hang the same mass on the equivalent spring – its extension is the same as the extension of the springs connected in parallel.

Circle the correct answer for each of the following:

(1 pt.) **a.** Based on the results of your measurements, the spring force constant k_T, equivalent to two springs (the force constant of each is k) connected in parallel is:

1. $\frac{1}{2}k$ 2. k 3. 2k 4. 4k

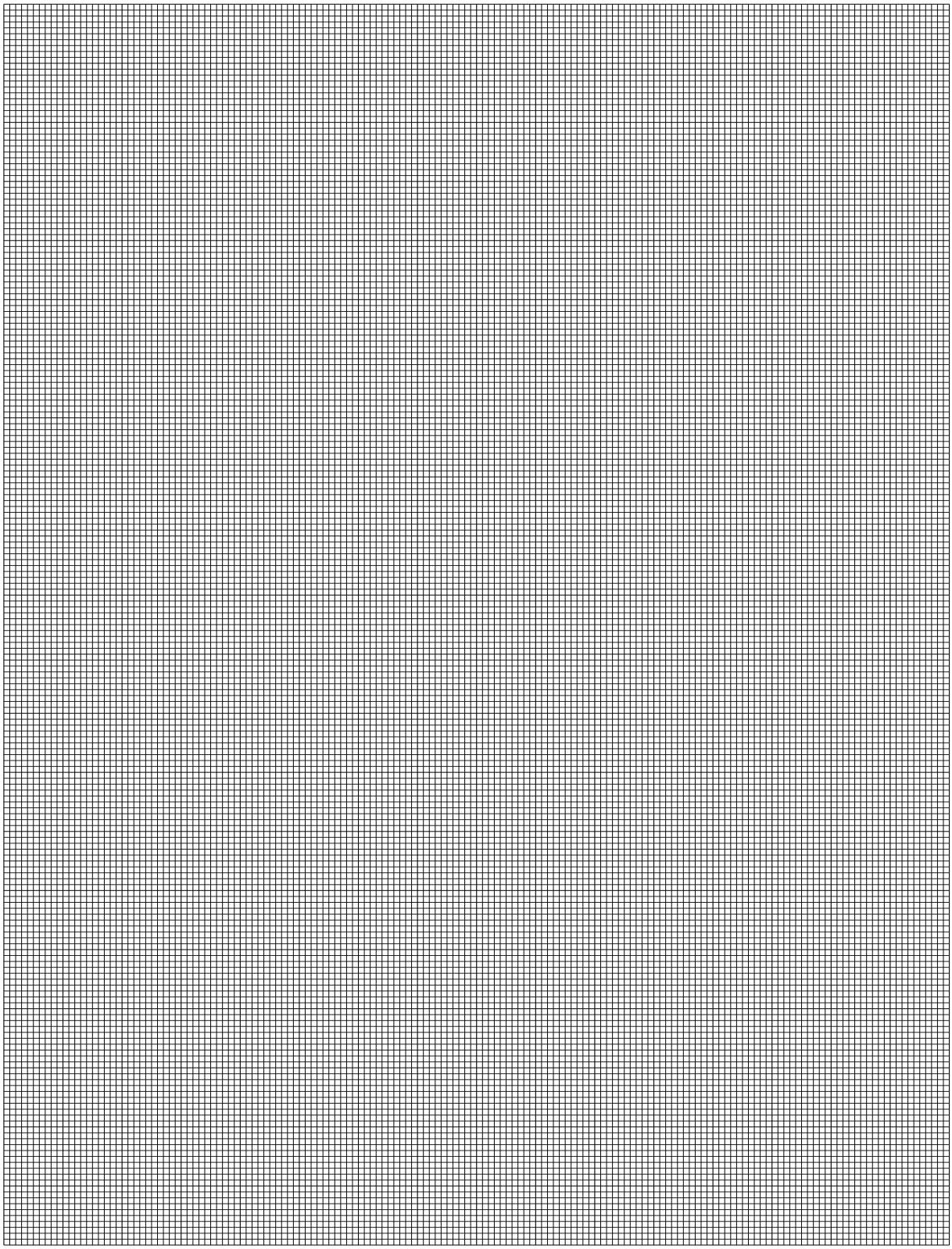
(1 pt.) **b.** Based on the results of your measurements, the spring force constant k_T, equivalent to three springs (the force constant of each is k) connected in parallel is:

1. 9k 2. k 3. $\frac{1}{3}k$ 4. 3k

(1 pt.) **c.** According to your answers in a. and b., the spring force constant k_T, equivalent to n identical springs (the force constant of each is k) connected in parallel is:

1. $\frac{n}{2}k$ 2. k 3. $\frac{1}{n}k$ 4. nk

Continue to page 7



You have an additional millimeteric paper on page 14, if needed.

Continue to page 8

Section 2 – Finding the force constant of a spring in a dynamic method by connecting springs in parallel

Here we will calculate the force constant of **one** spring, out of measuring the time period T of a body which performs a simple harmonic motion while it is hanged on identical springs connected in parallel.

Theoretical background

A body which is connected to a spring is performing a simple one-dimensional, harmonic movement, along a certain axis. The equivalent of the external forces acting on it along this axis is a restoring force (the equivalent force aimed towards the point of equilibrium of the body at rest):

$$\Sigma\vec{F} = -k\vec{x}$$

That is, the size of the force F is linear to displacement x of the body from its point of equilibrium.

We can show that the time period T of the body making the simple harmonic movement is given by:

$$T = 2\pi\sqrt{\frac{m}{k}}$$

When m is body mass and k is the force constant of the spring.

When the body is connected to n identical springs connected in parallel, the time period T will be:

$$T = 2\pi\sqrt{\frac{m}{n \cdot k}}$$

Conducting the Experiment

Question 8 (3 points)

Remove the ruler and four springs from the upper panel, leave only one spring connected to the middle hole in the upper metal plate. Attach the ring with the 4 weights to the attached metal plate and hang them on the spring, as shown in Figure D.

Measure the time period as follows:

– Let the system out of balance **slightly**, by lifting it up by 1 cm, and hold it steady before releasing it into motion.

– Release the system from a state of rest to vertical movement. Allow the system to move a few times, make sure the movements occur along a vertical line in an orderly manner, only then start the stopwatch when the system is at the end of its course. Count twenty movements and stop the stopwatch.

Notice: Make sure that the swinging system does not hit the frame or the desk.

Write the result you have received and the time period of the movements in the first line **in Table 2**, in Question 9.

Continue to page 9

Question 9 (12 points)

Measure the time period as described in question 8 for two springs that are hanged in parallel, as shown in Figure E. Increase the number of springs attached in parallel (3, 4 and 5) as shown in Figures F, G and H, accordingly. Each time, measure the time of twenty movements and calculate the time period.

Write the results of your measurements **in Table 2**.

Table 2

No. of Measurement	**Number of Springs n**	**Time of Twenty Movements 20T [ ]**	**Time Period T [ ]**	**[ ]**	**$\frac{1}{n}$**
1					
2					
3					
4					
5					

Question 10 (6 points)

(2 pts.) **a.** Based on the theoretical background, determine (circle) which of the following variables has a linear connection with the variable $\frac{1}{n}$.

1. T 2. T^2 3. $\sqrt{T}$ 4. $\frac{1}{T}$

Explain your decision.

(2 pts.) **b.** Based on your decision in a., write the variable you have selected and its physical units in the head of the empty column **in Table 2**. Write the value of the variable and the corresponding value of $\frac{1}{n}$ in every line.

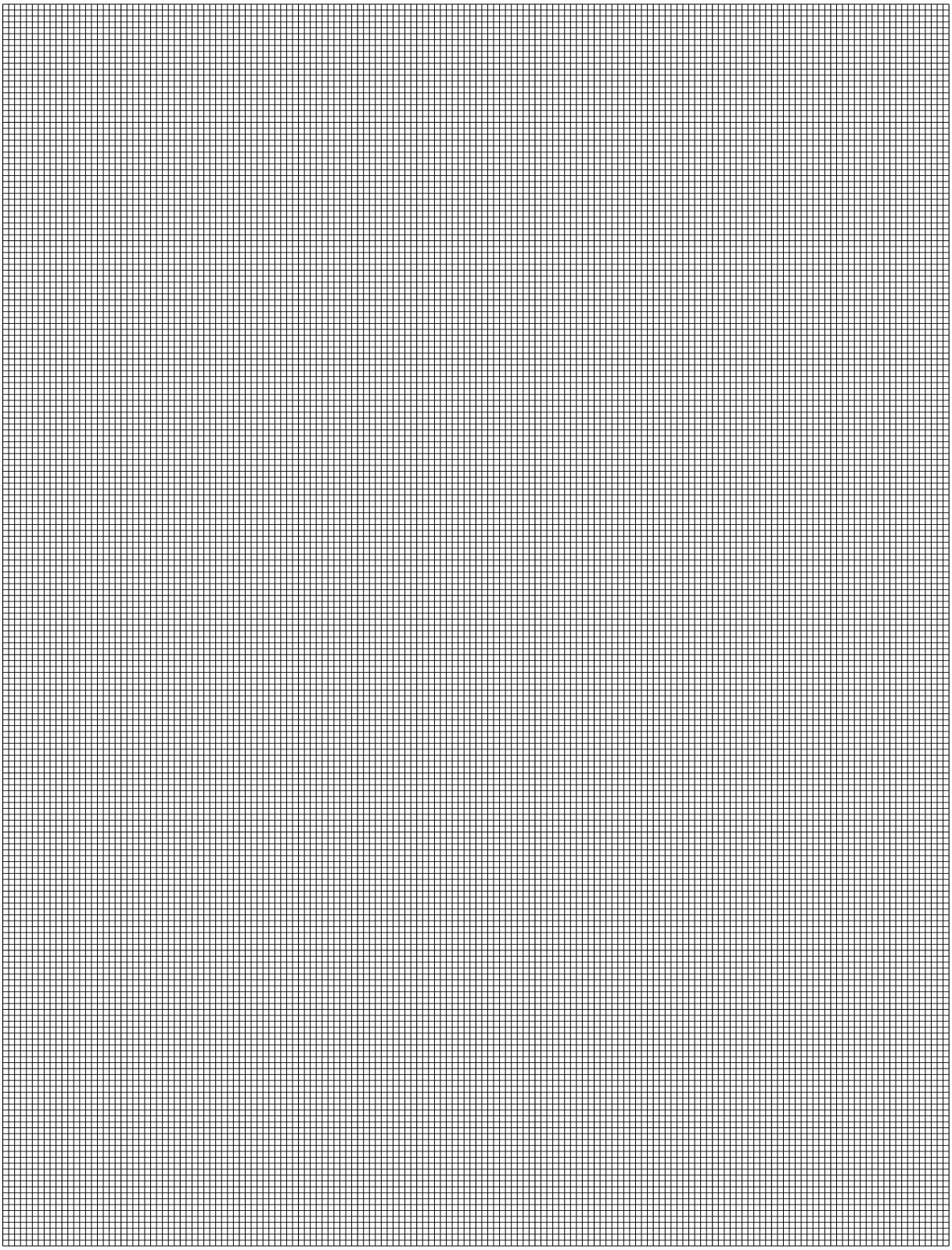
(2 pts.) **c.** Write which is the dependent variable and which is the independent variable.

Question 11 (10 points)

(5 pts.) **a.** On the millimeteric paper (on the next page), draw a scattering diagram which will describe the linear connection between the dependent variable and the independent variable from question 10, according to the results you wrote **in Table 2**.

(5 pts.) **b.** Draw a trend line in the scattering diagram (the straight line that is most suitable to the diagram).

Continue to page 10



You have an additional millimeteric paper on page 14, if needed.

Continue to page 11

Question 12 (8 points)

(4 pts.) **a.** Calculate the slope of the trend line, and write its physical units.

(4 pts.) **b.** Using the slope of the trend line, find the force constant k of one spring (by the connection written in the theoretical background), and write its physical units. Present your calculations.

Question 13 (4 points)

(3 pts.) **a.** Calculate the deviation (in percentage) between the force constant received in Section 1 of the experiment, we will call it k_1, and the force constant received in Section 2 of the experiment, we will call it k_2, according to the expression:

$$\frac{\text{The difference between the two force constans}}{\text{The average of the two force contants}} \cdot 100 = \frac{\left|k_1 - k_2\right|}{\left(\frac{k_1 + k_2}{2}\right)} \cdot 100 =$$

(1 pt.) **b.** Write your opinion on the deviation result you have received.

Continue to page 12

Part B: Questions from the Compulsory Experiments (10 points)

Answer one of the questions 14-15 (10 points for each).

Question 14 (10 points)

A Collision in Two Dimensions

(3 pts.) **a.** How does dropping the balls from height h enables us to refer to the horizontal falling-distances of the balls as their speed vectors?

(3 pts.) **b.** Does the Law of Momentum Conservation exists in the three axes while the balls are falling?
In your answer, refer to each axis separately and explain your decisions.

(2 pts.) **c.** What angle is received, after an inelastic collision between two identical balls, between the speed vector of the colliding ball and the speed vector of the stationary ball?

(2 pts.) **d.** Can you perform Part B of the experiment when the steel ball is at the bottom of the rail, while the marble with the smallest mass is the one which is released off course and collides head on into it? Explain your answer.

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Question 15 (10 points)

EMF and Terminal Voltage

(3 pts.) **a.** In this experiment we assemble an electric circuit, with which we can calculate the EMF of the battery and its internal resistance. Draw the electric circuit including the battery, a potentiometer and ideal testers (a voltmeter and an ampermeter).

(2 pts.) **b.** Write an expression to the current in the circuit as a function of the battery EMF and the resistances in the circuit.

(3 pts.) **c.** Draw the diagram describing the connection between the terminal voltage and the current in the circuit. Explain how we can find the following values in the diagram: battery EMF, short-circuit current and internal resistance of the battery.

(2 pts.) **d.** Why does the terminal voltage decrease when the current in the circuit increases? Explain your answer.

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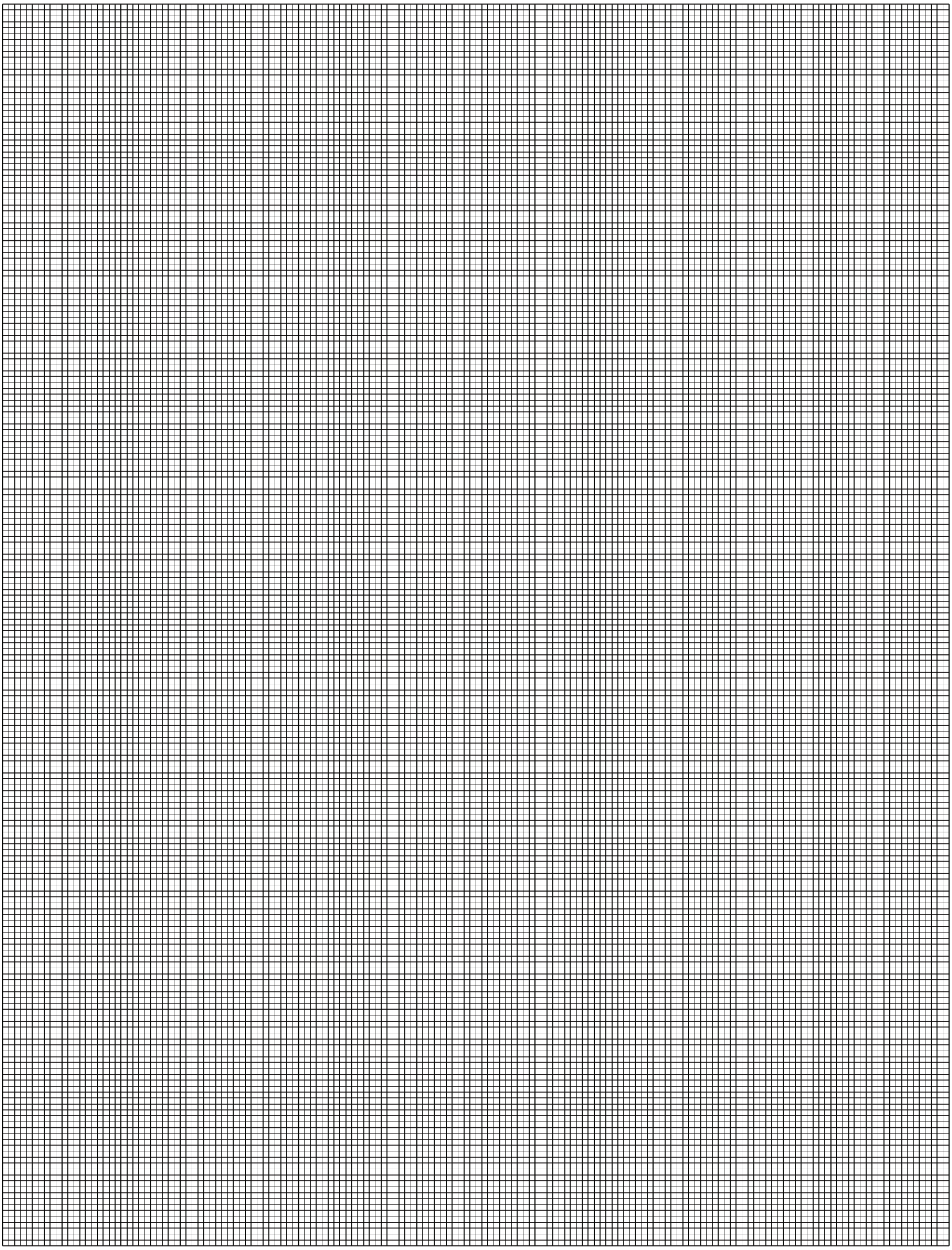

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Good luck !

מדבקת משגיח
ملصقة مراقب

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בהצלחה, מועצת התלמידים והנוער הארצית"
"معك في كلّ مكان، وفي البجروت أيضًا.
بالنجاح، مجلس الطلّاب والشبيبة القطريّ"