

State of Israel

Ministry of Education

Type of Examination:

Highschool matriculation

Exam date: Summer 2015

Exam Code: 917554

Appendix booklet:

Appendix A - for Question 3

Appendix B - millimeter paper

Appendix C - administrator comments

Physics data and formulas
for 5 units

מדינת ישראל

משרד החינוך

סוג הבחינה: בגרות לבתי-ספר על-יסודיים

מועד הבחינה: קיץ תשע"ה, 2015

סמל השאלון: 917554

חוברת נספחים: נספח א' - לשאלה 3

נספח ב' - נייר מילימטרי

נספח ג' - דף הערות לבוחן

נתונים ונוסחאות בפיזיקה

לחמש יח"ל

תרגום לאנגלית (3)

Physics – Research Laboratory

For students of 5 units of study

פיזיקה – מעבדת חקר

לנבחנים ברמת חמש יחידות לימוד

Instructions

- Duration of the exam:** two hours
- Structure of the exam and evaluation key:** This questionnaire consists of eight questions. You need to answer **all** questions 1–6 and **one** of questions 7–8.
Total: 100 points.
- Allowed materials:** calculator, protractor and ruler.
- Special instructions:** pencil may be used for drawing/sketching only.

Note to test administrator: write your comments in Appendix C in the appendix booklet.

This questionnaire consists of 8 pages, an appendix booklet and formulas.

הוראות לנבחן

- משך הבחינה:** שעותיים.
- מבנה השאלון ומפתח הערכה:**
בשאלון זה שמונה שאלות. עליך לענות על **כל** השאלות 1–6, ועל שאלה **אחת** מבין השאלות 7–8.
סה"כ – 100 נקודות.
- חומר עזר מותר לשימוש:** מחשבון, מד-מעלות וסרגל
- הוראות מיוחדות:** מותר להשתמש בעיפרון לסרטטים בלבד.

הערה לבוחן: רשום את הערותיך בנספח ג' שבחוברת הנספחים.

בשאלון זה 8 עמודים, חוברת נספחים ונוסחאות.

Good Luck!

Continue to next page ►

בהצלחה!

המשך מעבר לדף ►

Part A: Exploring the minimum deflection angle of light transfer in a prism (90 points)

Theoretical background

The experiment described on page 4 explores the minimum deflection angle in transfer of a light ray through a prism suspended in the air.

Figure 1 shows a prism with an angle $\angle BAC = \theta$. The light enters the prism via side AB and leaves it via side AC. The refraction coefficient of the prism material is n .

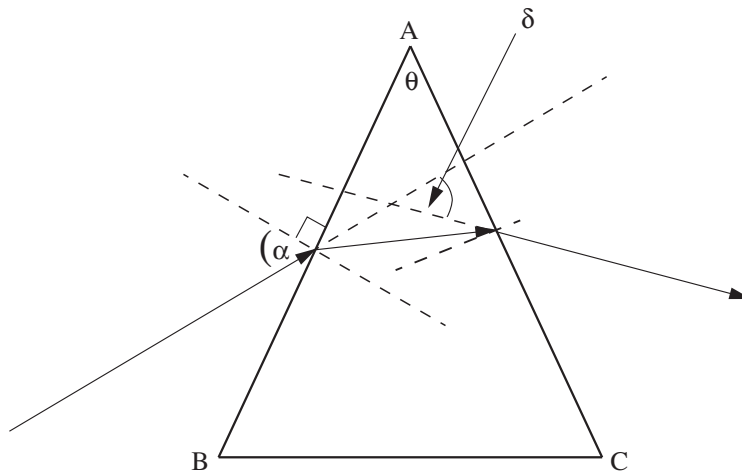


Figure 1

The angle labeled δ in Figure 1 is called the deflection angle. The deflection angle is the angle created between the direction of the ray entering the prism and the direction of the ray exiting it.

If the angle of the entering ray, angle α , is changed – the deflection angle, δ , changes as well.

The minimum deflection angle, δ_m , is obtained when the ray crossing the prism is perpendicular to the bisector of θ .

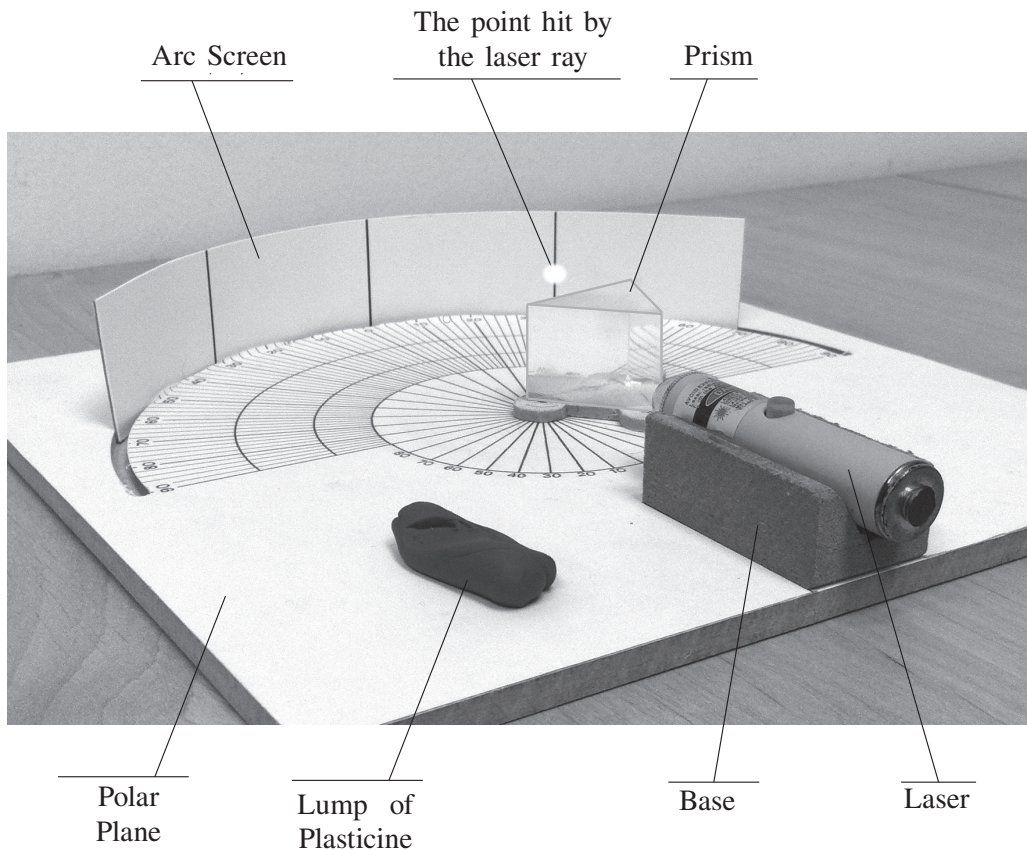
The relationship between angle θ and the minimum deflection angle, δ_m , is described by the following formula:

$$\sin\left(\frac{\theta + \delta_m}{2}\right) = n \cdot \sin\left(\frac{\theta}{2}\right)$$

List of equipment

1. Two prisms with rotation pivots, made of the same transparent material.
The angles of the prisms:
Prism 1: 30° , 40° , 110°
Prism 2: 50° , 60° , 70°
2. A polar plane used as a base for the prisms and as a protractor, with a screw functioning as a pivot at its center
3. A laser emitting a narrow light beam
4. A movable arc screen marked with auxiliary lines
5. A protractor
6. A lump of plasticine

A photograph of the experimental system



The Experiment

- (20p.) 1. (2p) a. Position the arc screen so that central line marked on it coincides with the zero line marked on the polar plane. Place the laser in the base, and direct the laser ray using the plasticine lump so it is parallel to the zero line and so the outgoing ray hits the screen at approximately half its height. Start the measurements using Prism 1 (30° , 40° , 110°). Use Figure A in Question 1 to determine which vertices of Prism 1 are 30° and 40° . Use Figure B in Question 1 to determine which vertices of Prism 2 are 50° and 60° . Start your measurements for $\theta = 30^\circ$. Place the 30° vertex of Prism 1 on the pivot so that the screw is inside the hole at the base of the prism. Make sure that the exposed part of the hole is turned towards the laser (use the following figures).

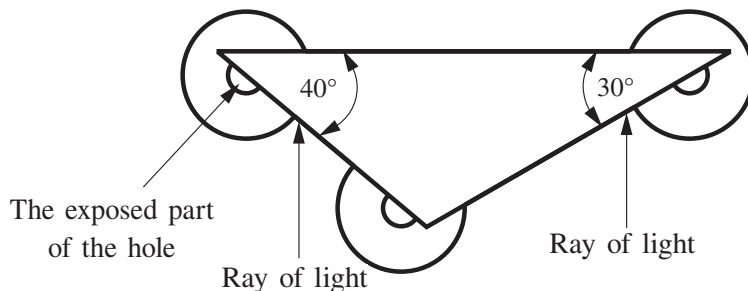


Figure A for Question 1 – Prism 1

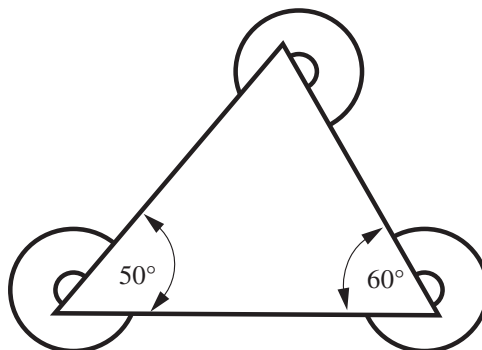


Figure B for Question 1 – Prism 2

- (3p) b. Activate the laser by pressing the switch and check that a spot of light appears on the arc screen (sometimes an elongated stain of light appears instead. In such case, the point where the light is most intense is considered to be the measurement point). Rotate the prism continuously, verifying that the light enters it via the smaller side of the angle. As you rotate the prism you will notice the spot of light moving on the screen. Continue rotating the prism until the point where the spot of light changes its direction. This is the minimum deflection point (where the deflection angle is minimal).
- (3p) c. To measure the minimum deflection angle, move the arc screen so that the spot of light unites with one of the auxiliary lines. Determine the location of the spot of light as precisely as possible. Write the deflection angle, δ_m , in your notebook.

Note that any spots of light coming from other sides of the prism need to be ignored.

- (3p) d. Repeat the measurement of δ_m (sections a to c) for the other sharp angle of the prism, $\theta = 40^\circ$.
- (9p) e. Replace Prism 2 with Prism 1, and repeat the measurement of δ_m for all angles of the prism (50° , 60° , 70°). The table below shows additional δ_m values which were measured in a separate experiment with a prism made of the same material.

Copy the table to your notebook. Fill in the results you received for Prism 1 and for Prism 2 in the appropriate places.

(°) θ	0	10	20	30	40	50	60	70
(°) δ_m	0	5.5	10					

Findings of the experiment

(12p) 2. On the millimeter paper in appendix B, draw a scatter graph describing the dependence of δ_m on angle θ of the prism (use the table).

(10p) 3. Figures A1, A2 and A3 in Appendix A describe an isosceles prism ($AB = AC$), with a main angle of $\theta = 45^\circ$.

A ray of light enters the prism. It enters at point P and exits through the opposite side.

The refraction index of the prism is $n=1.5$.

Write your answer to Question 3 in **Appendix A in the appendix booklet**.

(2p) a. On Figure A1, mark the deflection angle δ created between the ray entering the prism and the ray exiting it. Measure the angle with a protractor. Write down the result in the appendix.

(2p) b. In Figure A2, the angle of incidence on entering the prism is $\alpha = 60^\circ$. This angle is larger than the one in Figure A1. Add the deflection angle δ to Figure A2 and measure it. Write down the result in the appendix.

(2p) c. In Figure A3, the angle of incidence on entering the prism is $\alpha = 10^\circ$. This angle is smaller than the one in Figure A1. Add the deflection angle δ to Figure A3 and measure it. Write down the result in the appendix.

(4p) d. Use Figures A1, A2 and A3 (on which you marked the deflection angles δ) to describe the movement of the ray exiting the prism as angle α is changed continuously from 60° to 10° by rotating the prism counterclockwise.

(25p) 4. (5p) a. It is known that for small β angles, measured in radians, $\sin \beta \approx \beta$ holds. Use the theoretical background to show that for small θ angles, measured in radians, the relationship $\delta_m = (n - 1) \theta$ holds.

(10p.) b. The approximate relationship which you developed in section a holds in this experiment for θ values smaller than 42° , with a relative accuracy of up to 10%.

Add the trend line for the approximate relationship onto the scatter graph you drew in Question 2.

(10p.) c. Use the trend line to calculate the refraction index n of the prisms used in the experiment.

Questions about the experiment

- (11p) 5. (5p) a. What is the physical phenomena which can be used to explain why δ_m cannot be measured when $\theta = 110^\circ$? Explain your answer (use the drawing in which the light beam passing through the prism is perpendicular to the bisector of angle θ).
- (6p) b. Estimate the maximal θ for which δ_m can be measured with the prisms used in the experiment. Explain the basis for your evaluation.
- (12p) 6. In another experiment, with a prism made of a different material, a deflection angle δ_m smaller than that measured in the first experiment (whose results were described above) was measured for $\theta = 50^\circ$. The same measuring system was used in both experiments.
- (5p) a. Is the refraction index of the material of the prism used in the second experiment larger, smaller or equal to the one used in the first experiment? Explain your answer.
- (7p) b. Is the relative error in measuring δ_m in the second experiment larger, smaller or equal to the relative error in the first experiment? Explain your answer.

Attach examinee stickers to the appropriate places on the cover of the index booklet and add it to your test booklet.

Questions about the obligatory experiments

Answer one of questions 7–8 (each question – 10 points)

- (10p) 7.** This question relates to the experiment “Tangent galvanometer”.
- (2p) a. What is the objective of the experiment?
 - (3p) b. Present the list of equipment for this experiment.
 - (2p) c. In this experiment there is significance to the direction in which the system is set. What is this direction? Explain how the direction makes it possible to find the magnitude of the magnetic field.
 - (3p) d. Several students were debating about which compass is best for conducting the experiment: a compass with a long needle or with a short needle. Give one possible argument in favor of each option.
- (10p) 8.** This question relates to the experiment “Two dimensional collision”.
- (2p) a. Why it is important to mark the exact point where the incident ball leaves the track on the white sheet of paper spread on the floor?
 - (2p) b. Describe how to determine the exact points where the two incident balls leave the track.
 - (3p) c. What is represented by the horizontal distances which the balls passed following the collision in each stage of the experiment?
 - (3p) d. In one of the stages of the experiment you used masses which were not identical. Explain how it is possible to prove the existence of the momentum conservation law at this stage of the experiment.

Good Luck!

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חוברת נספחים

לשאלון פיזיקה מעבדת חקר

סמל שאלון 917554

קיץ תשע"ה

בחוברת זו 5 עמודים

תרגום לאנגלית (3)

Appendix Booklet

For the Physics Research Laboratory questionnaire

Exam Code: 917554

Summer 2015

This booklet consists of 5 pages

ב ה צ ל ח ה !

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הערכה שלישית

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הערכה שנייה

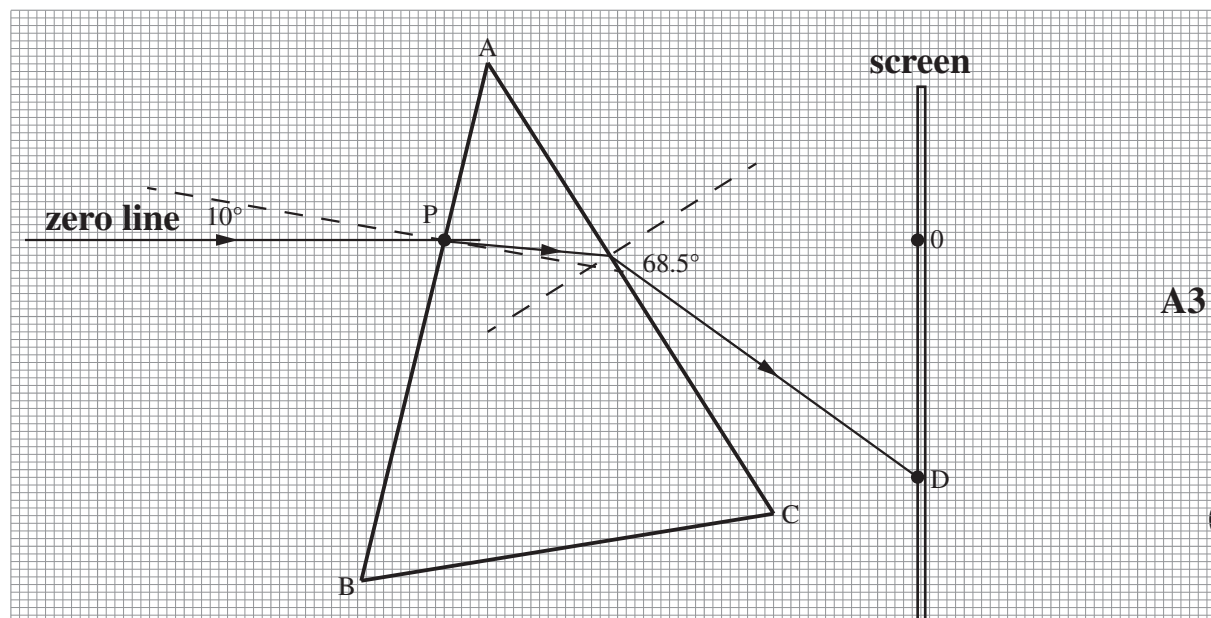
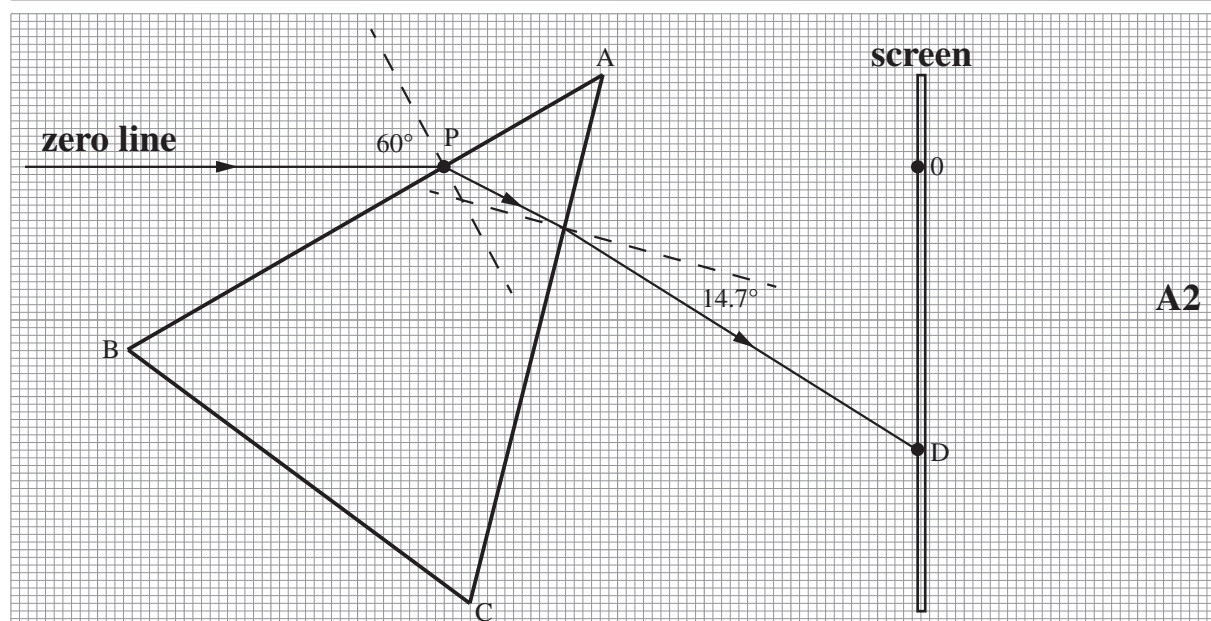
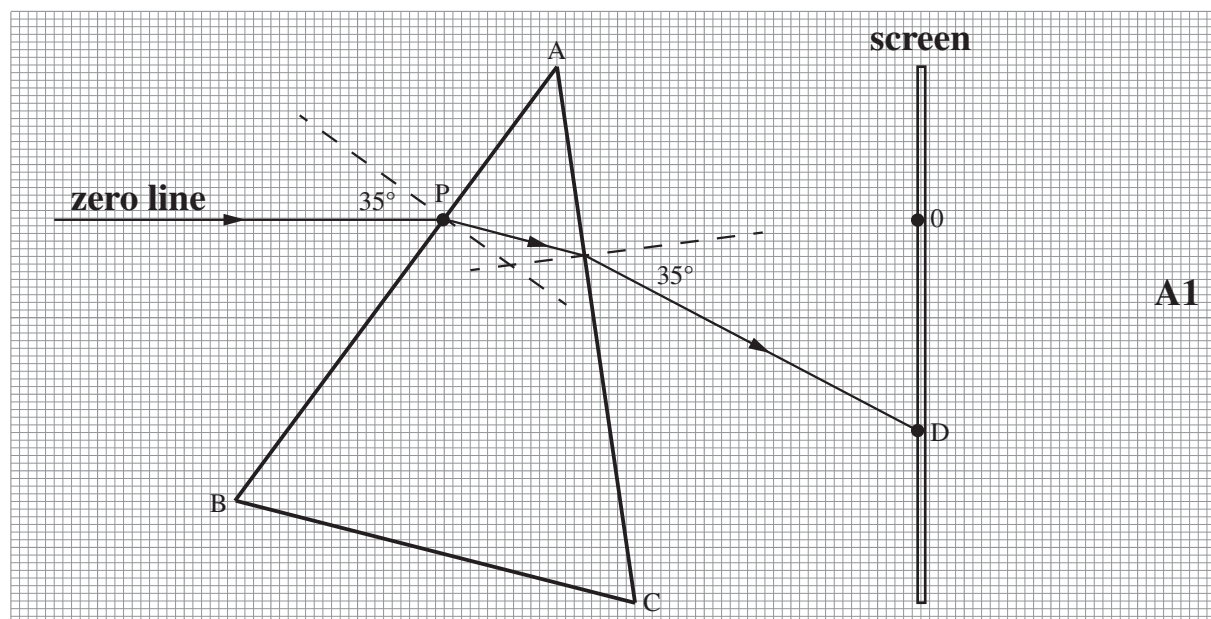
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הערכה ראשונה

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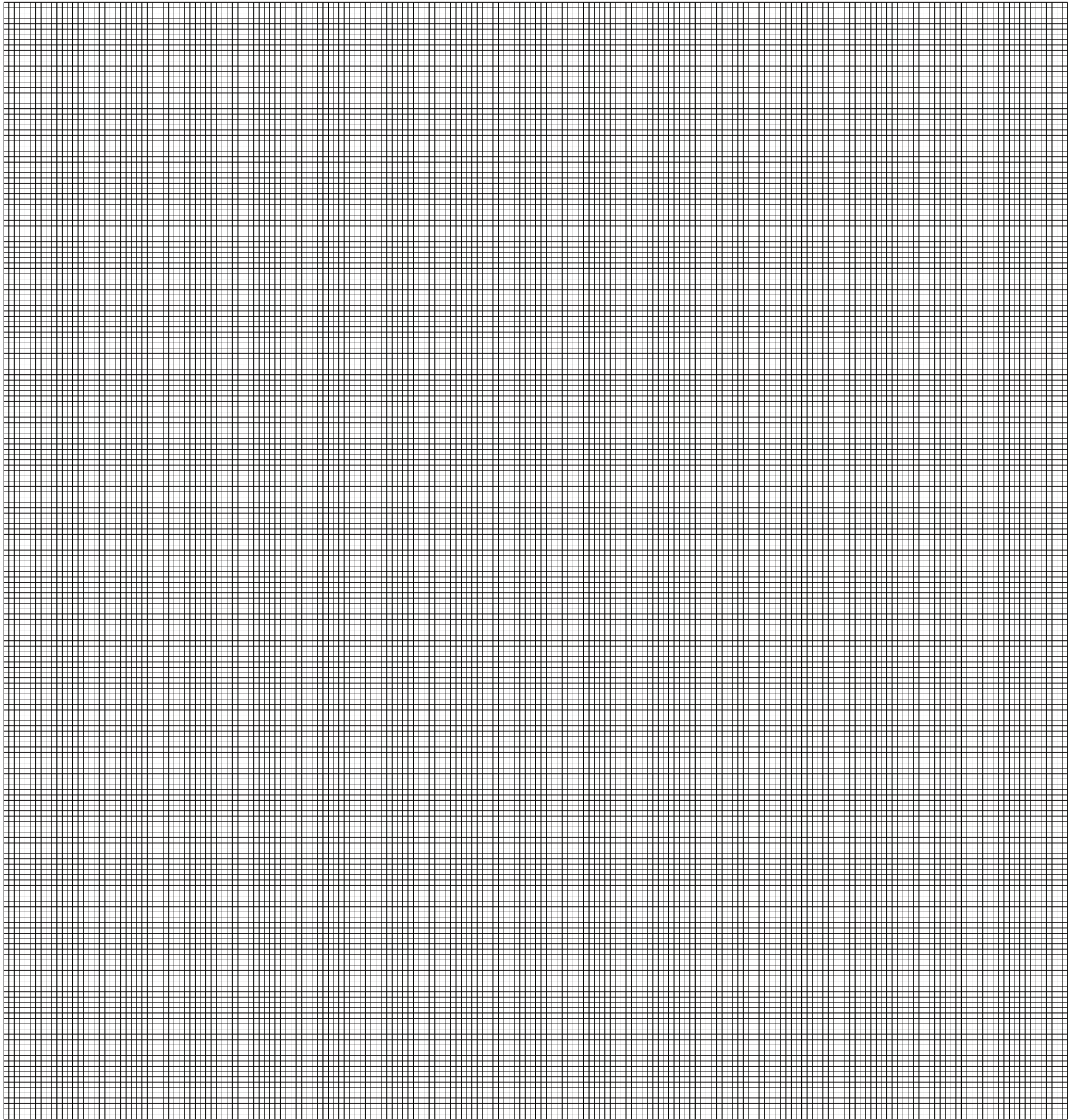
Appendix A



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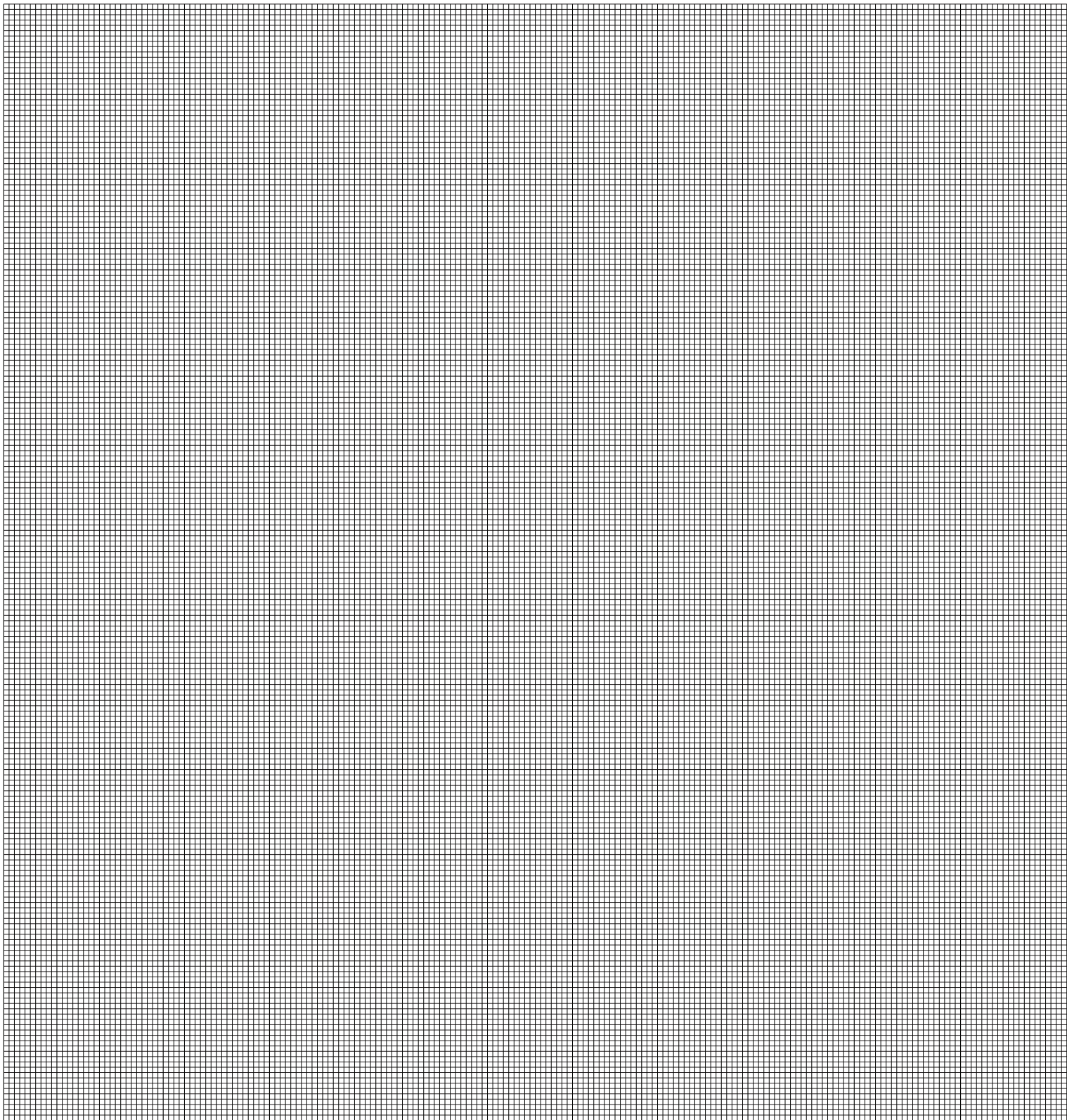


Appendix B





Appendix B





Appendix C

Examiner Obesrvations

מדבקת משגיח

ملصقة مراقب

"אתך בכל מקום, גם בבגרות.
בהצלחה, מועצת התלמידים והנוער הארצית"
"معك في كل مكان، وفي البجروت أيضًا.
بالنجاح، مجلس الطلاب والشبيبة القطري"