רפורמה

המינהל הפדגוגי

משרד החינוך

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. מותר לכתוב משני צדי הדף במחברת הבחינה.
4. לטיוטה ישמשו אך ורק דפי מחברת הבחינה. **אין לתלוש או להוסיף דפים**. מחברת שתוגש לא שלמה תעורר חשד לאי־קיום טוהר הבחינות.
5. אין לכתוב שם בתוך המחברת, משום שהבחינה נבדקת בעילום שם.
6. אין להוסיף או לשנות שום פרט במדבקות, כדי למנוע עיכוב בזיהוי המחברת וברישום הציונים.

בהצלחה!

מדבקות לנבחן
ملصقة ممتحن

18 מועד 21
موعد

37 סמל בי"ס 32
رقم المدرسة

31 מס' תעודת זהות 23
رقم الهوية

הדבק כאן ↑ מדבקת נבחן (ללא שם)
الصق هنا ↑ ملصقة ممتحن (بدون اسم)

17 סמל שאלון 12
رقم النموذج

שם השאלון ויחידות לימוד
اسم النموذج والوحدات التعليمية

הדבק כאן ↑ מדבקת שאלון
الصق هنا ↑ ملصقة نموذج امتحان

* הוראות בשפה הערבית מעבר לדף

* التّعليمات باللّغة العربيّة على ظهر الصّفحة

الإدارة التّربويّة | **وزارة التّربية والتّعليم** | **القسم الكبير للامتحانات**

دفتر امتحان

تحيّة للممتحَنين وللممتحَنات !

الرجاء قراءة التعليمات في هذه الصفحة والعمل وفقًا لها بالضبط. عدم تنفيذ التعليمات قد يؤدّي إلى عوائق مختلفة وحتّى إلى إلغاء الامتحان. أُعدّ الامتحان لفحص تحصيلاتك الشخصيّة، لذلك يجب العمل بشكل ذاتيّ فقط. أثناء الامتحان، لا يُسمح طلب المساعدة من الغير ويُمنع إعطاء أو أخذ موادّ مكتوبة أو الحديث.

لا يُسمح إدخال موادّ مساعدة – كتب، دفاتر، قوائم – إلى غرفة الامتحان، ما عدا "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 الدفتر للمراقب، ومغادرة غرفة الامتحان بهدوء.

يجب المحافظة على نزاهة الامتحانات!

تعليمات للامتحان

1. يجب التأكّد بأنّ تفاصيلك الشخصيّة مطبوعة على ملصَقات الممتحَن التي حصلت عليها، وبأنّ تفاصيل نموذج الامتحان المعدّ لك مطبوعة على ملصَقات نموذج الامتحان التي حصلت عليها.
2. في حال عدم حصولك على ملصَقة، يجب ملء التفاصيل في المكان المعدّ لملصَقة الممتحَن، بخطّ يد.
3. لا يُسمح الكتابة في هوامش الدفتر (في المنطقة المخطّطة)، لأنّه لن يتمّ مسح ضوئيّ لهذه المنطقة. يُسمح الكتابة على جهتَي الصفحة في دفتر الامتحان.
4. للمسوّدة يمكن استعمال صفحات من دفتر الامتحان فقط. **يُمنع نزع أو إضافة صفحات.** الدفتر الذي يُسلّم وهو غير كامل سيثير الشكّ بعدم الالتزام بنزاهة الامتحانات.
5. لا يُسمح كتابة الاسم داخل الدفتر، لأنّ الامتحان يُفحص بدون ذكر اسم.
6. لا يُسمح إضافة أو تغيير أيّة تفاصيل في الملصَقات، وذلك لمنع عوائق في تشخيص الدفتر وفي تسجيل العلامات.

نتمنّى لك النجاح!

State of Israel
Ministry of Education
Type of Examination: Highschool matriculation
Exam date: Summer 2017
Exam Code: 036386
Appendix: – Physics data and formulas for 5 units

Physics – Research Laboratory

In compliance with the Meaningful Learning reform program

Instructions

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

b. **Questionnaire structure and evaluation key:** This questionnaire consists of ten questions. You have to answer **all** questions 1-8 and **one** of questions 9-10.

Total: 100 points.

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

d. **Special instructions:** pencil may be used for drawing/sketching only.

e. Pages 17-18 may be used as draft paper.

Write all your drafts (outlines, calculations and so forth) in the exam booklet only, on pages 17-18. Writing drafts on any paper other than the test booklet can disqualify your exam!

This questionnaire consists of 19 pages and formula pages.

Good Luck!

Continue to next page ▶

מדינת ישראל
משרד החינוך
סוג הבחינה: בגרות לבתי־ספר על־יסודיים
מועד הבחינה: קיץ תשע"ז, 2017
סמל השאלון: 036386
נספח: – נתונים ונוסחאות בפיזיקה לחמש יח"ל
תרגום לאנגלית (3)

פיזיקה – מעבדת חקר

על־פי תכנית הרפורמה ללמידה משמעותית

הוראות לנבחן

א. **משך הבחינה:** שעתיים.

ב. **מבנה השאלון ומפתח ההערכה:**

בשאלון זה עשר שאלות. עליך לענות על **כל** השאלות 1–8, ועל שאלה **אחת** מבין השאלות 9–10.

סה"כ – 100 נקודות.

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

ד. **הוראות מיוחדות:** מותר להשתמש בעיפרון לסרטוטים בלבד.

ה. העמודים 17–18 משמשים כטיוטה.

כתוב **במחברת הבחינה בלבד**, בעמודים 17–18, כל מה שברצונך לכתוב **כטיוטה** (ראשי פרקים, חישובים וכדומה).
רישום טיוטות כלשהן על דפים שמחוץ למחברת הבחינה עלול לגרום לפסילת הבחינה!

בשאלון זה 19 עמודים ונוסחאון.

בהצלחה!

ההנחיות בשאלון זה מנוסחות בלשון זכר, אך מכוונות לנבחנות ולנבחנים כאחד.

המשך מעבר לדף ◀

Part A: Exploring the passage of light through gratings

Please answer all of questions 1–8.

Theoretical background

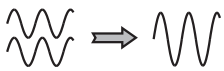
The world as we know it is composed of material and radiation. The main component of radiation in the universe is electromagnetic radiation. Visible light is just a small section of this radiation.

The three main parameters by which we describe electromagnetic radiation are velocity v [m/sec], frequency f [Hz = 1/sec] and wavelength λ [m]. The relationship between them is given in the formula $v = \lambda \cdot f$.

Waves in general, and particularly light waves, demonstrate the phenomena of **superposition** and **interference**. This means that when two or more waves meet and pass through each other, a new pattern appears in the area where they overlap, that is different than the pattern each wave has when moving by itself.

We distinguish between two different cases:

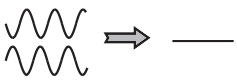
Constructive interference – when two or more waves reach the same place at the same time in the same phase, for example at the top point or at the low point of the wave. The displacements add up, as can be seen in Figure a1.



Constructive interference

Figure a1

Destructive interference – when two waves reach the same place at the same time in opposite phases, for example when one is at its top point and the other at its low point. Summing up the displacements can result in an equivalent displacement of zero, as can be seen in Figure a2.



Destructive interference

Figure a2

Different combinations of waves passing through each other create unique and fascinating patterns, which can show us much about the nature and properties of waves.

A **diffraction grating** is an optical component which splits the light hitting it to different directions. A diffraction grating which transmits that light is called a **transmission grating**, whereas a diffraction grating which reflects that light is called a **reflection grating**.

In this experiment we will use two types of diffraction gratings: a transmission grating, which is a transparency with multiple vertical, narrow parallel slits with an interval d between them; and a CD which serves as a reflection grating. When a laser beam is projected on the grating, each of the slits in the grating functions as a point source of the light emerging from it. The interference pattern of the light emitting from the slits can be seen on a screen located at a distance L from the grating. The points on the screen represent constructive interferences, expressed as maximal light intensity.

Continue to page 3

The letter k marks the order of interference (the ordinal number of a point of light on the screen, counting from the central point): k = 0,1,2…

N* marks the density of the slits on the grating (called "the grating constant"), for which the following relationship holds: N* = 1/d.

The grating equation is the mathematical relationship between the grating constant (N*), the wavelength of the light (λ) and the scattering angle (α_k) of the light emerging from the slits of the grating.

(1) $$\sin(\alpha_k) = k \cdot \lambda \cdot N^*$$

This formula is valid for both transmission gratings and reflection gratings, given the following conditions:

The laser beam is perpendicular to the grating plane; k is of a low order; for the distance d between the slits, $d \gtrsim \lambda$ and $d \ll L$.

The scattering angle (α_k), shown in Figure b, can be determined using the formula:

(2) $$\tan(\alpha_k) = \frac{x_k}{L}$$

where x_k is the distance between the central point of light on the screen and the k point to its right or left.

Note: for smaller angles, the following relationship holds: $\sin(\alpha_k) \approx \tan(\alpha_k)$

In this experiment, Δx is the distance between the central point of light and the two points of light adjacent to it, as described in Figure b.

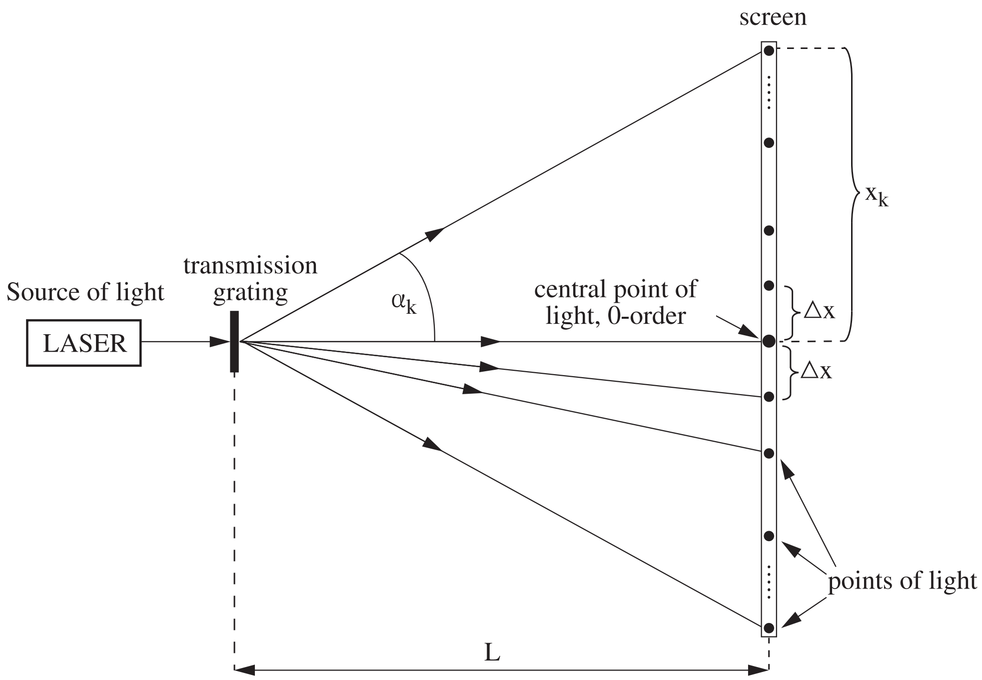


Figure b

Continue to page 4

Equipment

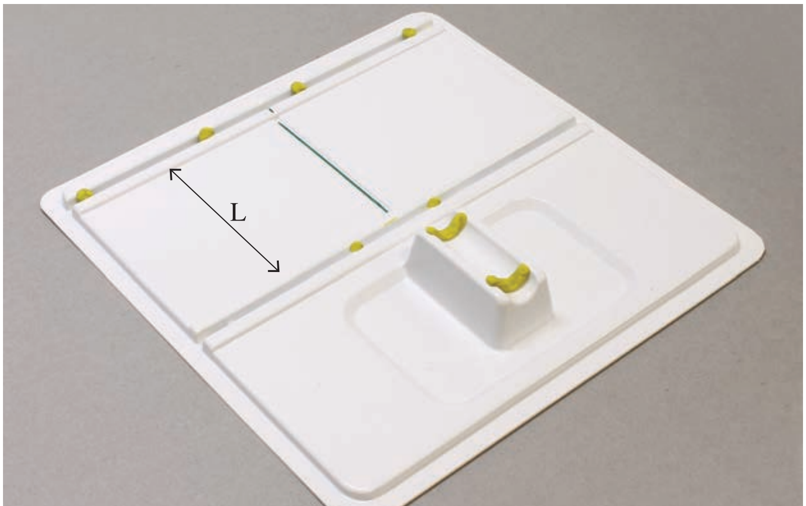
1. a surface on which the experiment apparatus will be placed
2. a laser pointer emitting a narrow light beam
3. four transparencies serving as transmission gratings: a grating transparency with a density of 190 $\frac{\text{lines}}{\text{mm}}$, two grating transparencies with a density of 500 $\frac{\text{lines}}{\text{mm}}$, and a grating transparency with a density of 1000 $\frac{\text{lines}}{\text{mm}}$
4. a CD serving as a reflection grating
5. a calibrated ruler serving as a screen
6. a calibrated ruler, with a round hole for the laser beam, serving as a screen
7. a mass of plasticine
8. a transparent plastic container
9. a 500 ml bottle of mineral water

The experiment

Warning: laser beam can be dangerous to the human eye; therefore it must not be pointed directly to your eyes or to those of other students.

Comments:

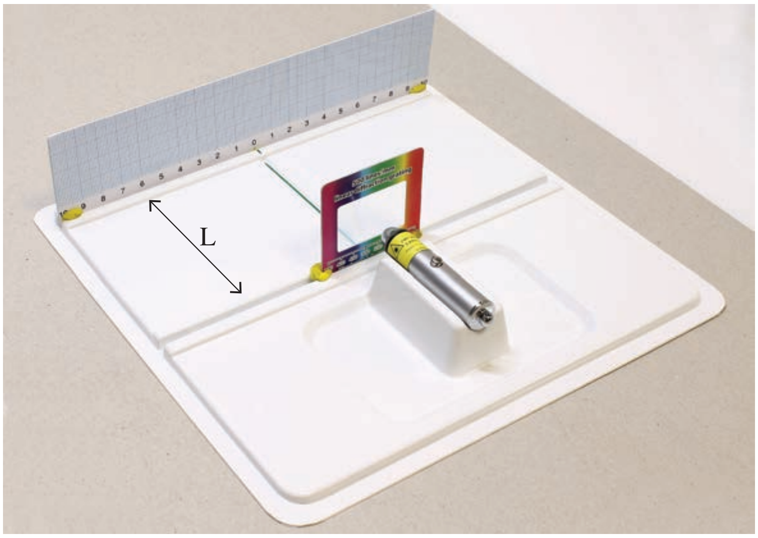
1. **When setting up the apparatus for the measurements, first stick plasticine (shown in yellow in the picture) to the surface as exemplified in Photograph 1, in order to stabilize the laser pointer and the other experiment components.**
2. **Touch only the frames surrounding the grating transparencies, not the transparencies themselves.**
3. **The distance between the grating and the ruler is L = 10 cm throughout the experiment.**



Photograph 1 of the experiment surface, L = 10 cm

Continue to page 5

Questions 1–4 refer to the experiment apparatus in Photograph 2.



Photograph 2 of the experiment apparatus with a grating transparency, L = 10 cm

Question 1 (4 pts.)

According to formulas (1) and (2) in the theoretical background, the distance between two adjacent points of light on the ruler ($x_{k+1} - x_k$) is constant when their corresponding scattering angles (α_k and α_{k+1}) are small. Show that the following relationship holds: $\mathbf{\Delta x = L \cdot \lambda \cdot N^*}$ **.**

Question 2 (10 pts.)

Place the calibrated ruler in the appropriate slit on the surface, as shown in Photograph 2, so that central line of the ruler (next to the digit zero) will fall in line with the green line marked on the center of the surface. Stabilize it with plasticine so that it is perpendicular to the surface.

Remove the plastic cover from the switch on the laser pointer, and adjust the pointer on its base so that the laser beam hits the central line of the ruler (which serves as a screen).

Place the grating with the density of $N^* = 1000\frac{\text{lines}}{\text{mm}}$ in the appropriate slit on the surface so that the writing on the grating is horizontal. Make sure that the grating is perpendicular to the surface plane, and stabilize it with plasticine. Turn on the laser pointer and look at the ruler.
Note: red points, which are part of the interference pattern, appear on the ruler. At these points there is constructive interference, expressed as maximal light intensity (peak points).

Continue to page 6

(2 pts.) **a.** Measure and write the distance Δx from the central point to the point to its right.

(2 pts.) **b.** Measure and write the distance Δx from the central point to the point to its left.

(3 pts.) **c.** Why is it best to take measurements from both sides of the central point, rather than from just one side?

(3 pts.) **d.** Calculate the average of the two measurements taken in sections (a) and (b).

Question 3 (14 pts.)

Place the grating with the density of $N^* = 500\frac{\text{lines}}{\text{mm}}$ in the appropriate slit on the surface so that the writing on the grating is horizontal. Make sure that the grating is perpendicular to the surface plane, and stabilize it with plasticine. Turn on the laser pointer and look at the ruler.

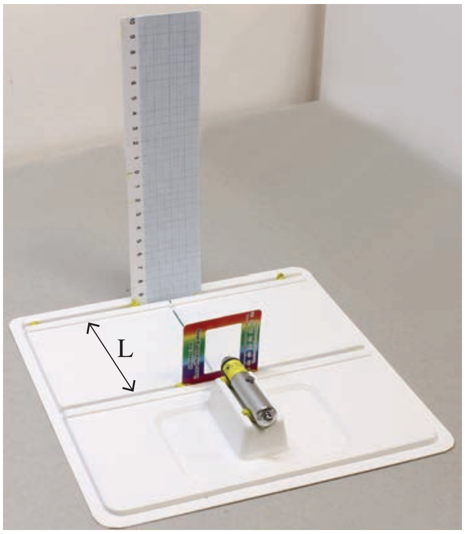
(3 pts.) **a.** Measure and write the distance between the two first-order points of light (adjacent to the central point of light from both sides). Using this measurement, find the distance Δx . Show your calculations.

(3 pts.) **b.** Explain why the method for finding the distance Δx in section (a) is more precise than the method in question 2.

(4 pts.) **c.** Find the distance Δx which would have been between two adjacent points of light had you used a grating with a density of $N^* = 300\frac{\text{lines}}{\text{mm}}$ in the experiment apparatus. Use your answer to question 1 and a result of one of the previous measurements. Show your calculations.

(4 pts.) **d.** Rotate both the grating and the ruler by 90° and place each of them in the appropriate slit. Make sure they are perpendicular to the surface plane and stabilize them with plasticine, as shown in Photograph 3 **(in the next page)**. Stabilize the top of the ruler with your hand, turn on the laser pointer and look at the ruler.
Give a qualitative explanation for the difference between the pattern received at the beginning of the question and the pattern received here.

Continue to page 7



Photograph 3 of the experiment apparatus with grating transparency and ruler rotated by 90˚, L = 10 cm

Question 4 (12 pts.)

Place the grating with the density of $N^* = 190\,\frac{\text{lines}}{\text{mm}}$ in the appropriate slit on the surface so that the writing on the grating is horizontal. Make sure that the grating is perpendicular to the surface plane, and stabilize it with plasticine. Return the ruler to its original position, turn on the laser pointer and look at the ruler.

(5 pts.) a.

(1 pt.) 1. Describe interference pattern seen on the ruler.

____

(4 pts.) 2. What do you think is the reason for this pattern? In your answer refer to the structure of the grating.

____

(2 pts.) b. Find and write the distance Δx between two adjacent "horizontal" points of light, as required in section (a) of question 3.

____

(2 pts.) c. Find and write the distance Δy between two adjacent "vertical" points of light, as required in section (a) of question 3.

____

(3 pts.) d. Is the grating constant in the horizontal dimension identical to that in the vertical dimension? Explain your answer.

____

Continue to page 8

Question 5 (10 pts.)

We shall now conduct the experiment with the CD. The CD has slits created with a laser beam, and it can serve as a reflection grating. The density of its slits is $N^* = 680\frac{\text{lines}}{\text{mm}}$. The light reflected from the CD creates several orders of peak points corresponding to the various k values, as explained in the theoretical background.

Figure 5a shows an aerial view of the experiment setup, and Figure 5b shows a frontal view of the CD.

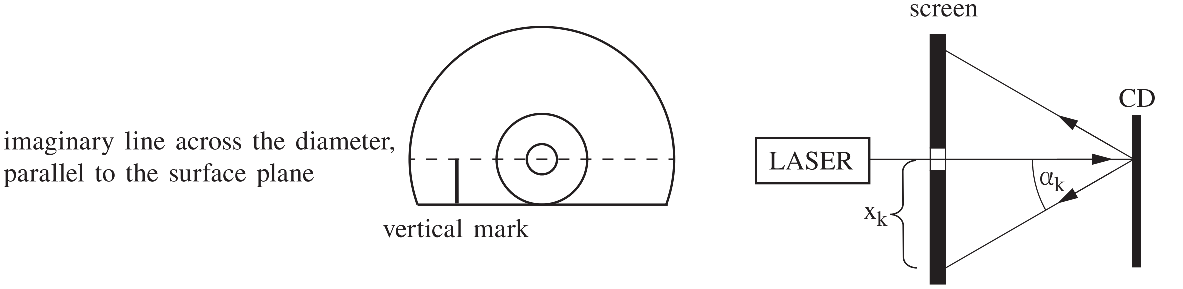


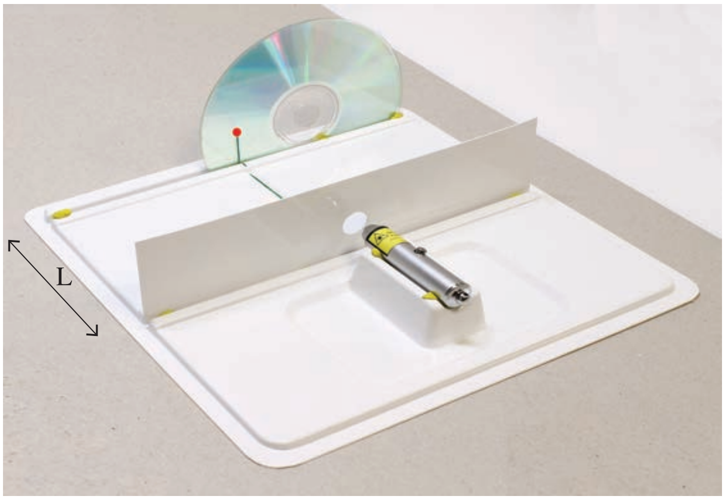
Figure 5b **Figure 5a**

Remove the ruler from the slit and replace it with the CD, as shown in Photographs 4 and 5 of the experiment setup **(on the next page)**, so that the horizontal mark on the CD falls in line with the green line on the center of the surface. Make sure that the CD is perpendicular to the surface plane, and stabilize it with plasticine. Now remove the transmission grating and replace it with the ruler with the round hole so that its calibrated side faces the CD, and stabilize it with plasticine so that it is perpendicular to the surface plane.

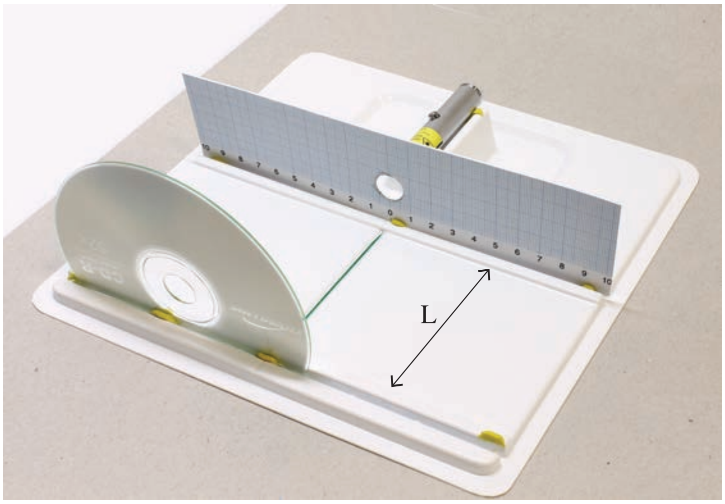
Turn on the laser pointer and position it so that the laser beam hits **the top part of the vertical mark** on the CD. Make sure that the point of incidence also falls on the imaginary line shown in Figure 5b. Photograph 4 **(on the next page)** shows the point where the laser beam hits the top of the vertical mark on the CD.

Look at the ruler – three red points, which are part of the interference pattern, appear on it. At these points there is constructive interference, expressed as maximal light intensity. When the CD is perpendicular to the surface plane, the peak points on the screen are **approximately** aligned in a horizontal line. If you do not see the three red points, slightly tilt the CD until they appear on the ruler.

Continue to page 9



Photograph 4 of the CD experiment setup, L = 10 cm



Photograph 5 of the CD experiment setup, L = 10 cm

Find the distance Δx between two adjacent points of light, as required in section (a) of question 3.

Continue to page 10

Question 6 (9 pts.)

In this experiment you have measured the distance Δx or calculated its values. Use formulas **(1)** and **(2)** from the theoretical background to calculate **tan** (α_1), α_1, and **sin** (α_1) for each case. Fill in the following table with your results:

question number / **variable**	**2d**	**3a**	**3c**	**4b**	**5**
N* $\left[\frac{1}{mm}\right]$					
Δ**x** [mm]					
tan (α_1)					
α_1 [°]					
sin (α_1)					

Question 7 (21 pts.)

(2 pts.) **a.** Use formula (1) from the theoretical background to explain why the relationship between the variables sin (α_1) and N* is linear.

____

____

(2 pts.) **b.** Use your answer to section (a) to determine which variable in the experiment is independent and which is dependent.

____

(4 pts.) **c.** On the millimeter paper in the **next page**, draw a scatter diagram of the dependent variable as a function of the independent variable, according to the table in question 6 and your answers to sections (a) and (b).
<u>Note:</u> You may also use an electronic worksheet according to the examiner instructions. If you use an electronic worksheet, print it, put your examinee sticker on the printout and add it to the questionnaire.

(4 pts.) **d.** Draw a trend line on your diagram.

(3 pts.) **e.** Calculate the slope of the trend line and write its measurement units.

____

____

(3 pts.) **f.** Find λ, the laser pointer wavelength.

____

(3 pts.) **g.** Give two examples of a measurement error which can be used to explain why the trend line does not **necessarily** pass through the origin.

____

Continue to page 11

On page 16 you will find additional millimeter paper that you may use if necessary.

Continue to page 12

Theoretical background (continued)

When light passes from one optically transparent material to another, it breaks and changes its direction (see Figure c).

The refractive index of a material is marked by n, and is defined as the ratio between the speed of light through vacuum (c) and the speed of light through the material (v) – namely, $n = c / v$.
The speeds of light passing through vacuum and through air can be regarded as approximately equal ($c = 3 \cdot 10^8$ m/sec), and therefore the refractive index of air is $n = 1$. The relationship between the angle of incidence α of light (through air) and its angle of refraction β (through another material) is derived from Snell's law, and is described by the formula:

(3) $$\sin\alpha = n \cdot \sin\beta$$

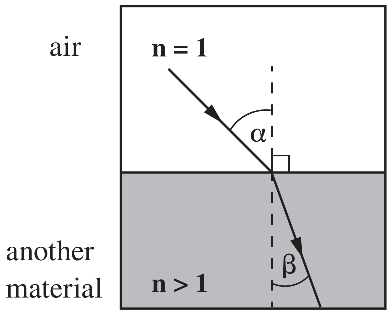


Figure c

If the light emitted from the grating slits passes through a material different than air (with a refractive index n), formula (**1**) from the theoretical background gives us this relationship:

(4) $$\sin(\alpha_k) = k \cdot \lambda' \cdot N^*$$

where: $$\lambda' = \frac{\lambda}{n}$$

Question 8 (10 pts.)

Remove the CD and the ruler with the round hole and replace once again the calibrated ruler and the grating with a density of $N^* = 500 \frac{\text{lines}}{\text{mm}}$ as done in question 3. (There is another grating with a density of $N^* = 500 \frac{\text{lines}}{\text{mm}}$ which you may use if the grating used previously was damaged).

Make sure that the grating and ruler are perpendicular to the surface plane, and stabilize them with plasticine. Place the transparent plastic container in the space between the grating and the calibrated ruler as shown in Photograph 6 of the experiment setup **(on the next page)**.

Carefully empty the water bottle into the container. Turn on the laser pointer so that the light passes through the water. The effect of the passage of light through the container walls can be considered negligible.

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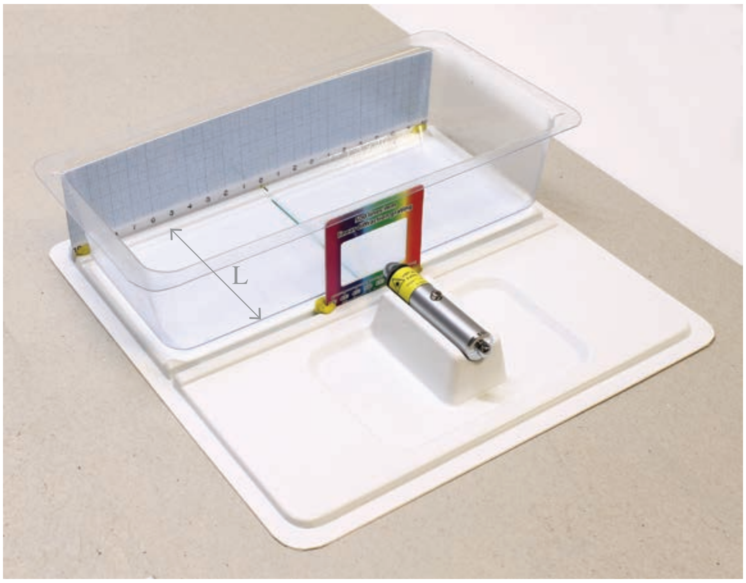

Photograph 6 of the experiment setup with the water container, L = 10 cm

(2 pts.) a. Measure the distance between the two first-order points of light seen on the ruler, calculate Δx and write it.

____

(2 pts.) b. Is the distance Δx calculated in section (a) larger, smaller or equal to the distance Δx calculated in question 3a? Explain your answer based on the theoretical background of the experiment.

____

(3 pts.) c. Use the distance Δx which you have calculated in section (a) to calculate the refractive index of water.

____

____

____

(3 pts.) d. Assuming that the refractive index of water is 1.33:

(2 pts.) 1. Find the relative error between the result received in section (c) and the given value of the refractive index.

____

(1 pt.) 2. Which factor can account for this error?

____

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Part B: Questions about the compulsory experiments

Answer one of questions 9–10 (10 points per question).

Question 9 (10 pts.)

Collision in two dimensions

In this experiment we mark the point hit by a steel ball falling from a rail, and then the points hit by two equal mass steel balls after they collided with each other. In the following figure the three straight lines show the horizontal courses of the three balls.

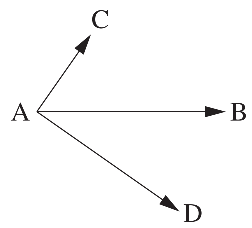

Figure 9

(3 pts.) **a.** What additional physical magnitude is represented by the horizontal displacement vectors the balls passed following the collision? Explain your answer.

(4 pts.) **b.** How is it possible to show geometrically that the overall kinetic energy of the two colliding balls is conserved after the collision? In your answer refer also to the conservation of energy equation in this experiment.

(3 pts.) **c.** Can Part B of the experiment be conducted with the steel ball at the end of the rail and the smaller-mass ball being released from the course? Explain your answer.

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Question 10 (10 pts.)

<u>Tangent galvanometer</u>

(3 pts.) a. Why is it important to keep the tangent galvanometer apart from other parts of the electric circuit and from iron objects?

____

____

(4 pts.) b. Explain why the coil is positioned so that the plane of the ring is in a north-south direction.

____

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(3 pts.) c. Why should the tangent galvanometer not be used in occasions that would cause the compass needle to deviate in large acute angles?

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Draft paper

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Draft paper

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Administrator comments

Good luck !

מדבקת משגיח
ملصقة مراقب

"אתך בכל מקום, גם בבגרות.
בהצלחה, מועצת התלמידים והנוער הארצית"

"معك في كلّ مكان، وفي البجروت أيضًا.
بالنجاح، مجلس الطلّاب والشبيبة القطريّ"