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compensating planimeter manual

This is unfortunate not only do they provide a remarkably quick and precise method for measuring areas, they have a fascinating history and are a delightful example of Green's theorem to show calculus students or colleagues, for that matter. Perhaps part of the reason polar planimeters are not discussed in calculus courses is that an explicit computation with the relevant vector field using Green's theorem is somewhat complicated. There are geometric explanations of planimeter operation that avoid Green's theorem, but it is debatable whether they are simpler. The resulting simplification should make the explanation of the polar planimeter accessible to any calculus student with a knowledge of partial derivatives and a modest background of linear algebra. We will also discuss two other important features specific to polar planimeters 1 the neutral circle, and 2 how compensating polar planimeters compensate. A brief description of planimeter operation A polar planimeter is a mechanical device used to measure the area of a region by tracing the boundary of the region. Figure 1 shows a compensating polar planimeter from the author's collection that indicates how it is used. A Closer Look at the Compensating Polar Planimeter All authors John Eggers Published online 25 February 2020 Fig. 1 A compensating polar planimeter. Display full size Fig. 1 A compensating polar planimeter. The instrument consists of three major components a 1 pole arm, 2 tracer arm, and 3 measuring wheel. The pole arm merely rotates about the pole, the tracer arm is connected to the free end of the pole arm by a pivot joint a ball and socket joint in the case of the compensating polar planimeter pictured in Figure 1 , and the measuring wheel is attached to the tracer arm with its axis parallel to the tracer arm.http://www.kompita.ru/files/upload/6es7216-2ad23-0xb0-manual.xml

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The area enclosed by a simple closed curved is measured by moving the tracer along the curve clockwise and recording the amount the measuring wheel moves which, as we will see, is proportional to the area enclosed by the curve. The dial keeps track of how many complete rotations are made by the measuring wheel, and the guide wheel merely balances the instrument so that it does not tip over while tracing. The polar planimeter is not the only type of planimeter; there are other types of planimeters. Analysis of planimeter operation The basic design of a polar planimeter is remarkable in its simplicity as indicated above, it consists of two rigid arms connected by a pivot joint. An idealized version is depicted in Figure 2. One arm, called the pole arm with length P, has an end fixed at a point 0, 0 called the pole, about which the pole arm is free to rotate. The other arm, called the tracer arm of length T, is connected at one end to the free end of the pole arm by a pivot joint a, b that is free to rotate. At the other end of the tracer arm is the tracer point x, y which is used to trace the boundary curve C assumed to be a simple closed curve of the region D. A measuring wheel W is attached to the tracer arm with its axis parallel to the tracer arm. In order to simplify the ensuing computations, the measuring wheel W of our idealized planimeter is drawn coincident with the tracer point. The vector in Figure 2 represents the unit vector perpendicular to the tracer arm in the direction of positive measuring wheel motion. A Closer Look at the Compensating Polar Planimeter All authors John Eggers Published online 25 February 2020 Fig. 2 An idealized polar planimeter. Display full size Fig. 2 An idealized polar planimeter. It is clear that placing the measuring wheel coincident with the tracer point is an impractical design for a usable planimeter.http://ankarapianofestival.com/userfiles/6es7197-1lb00-0xa0-manual.xml

However, the computations resulting from placing it there in our idealized planimeter will be correct since, as we will see, the displacement M of the measuring wheel during a normal tracing operation is independent of the placement of the measuring wheel W along the tracer arm. We define normal tracing operation to mean that the curve is traced with the pole of the planimeter outside the region enclosed by the curve. We will consider what happens when the pole of the planimeter is placed inside the region enclosed by the curve in the “The neutral circle” section of this paper. To see that the total wheel displacement M during a normal tracing operation is independent of the placement of the measuring wheel, we first observe that the displacement of a tracer arm can be decomposed into a component perpendicular to the tracer arm and a component arising from rotation about the pivot, as indicated in Figure 3. The parameter w represents the displacement of the measuring wheel W from the pivot a, b along the tracer arm. Note that on some planimeters, the pivot is between the measuring wheel and the tracer point, in which case w would be negative. A Closer Look at the Compensating Polar Planimeter All authors John Eggers Published online 25 February 2020 Fig. 3 Decomposition of wheel motion. Display full size Fig. 3 Decomposition of wheel motion. As indicated in Figure 3, a wheel displacement. M resulting from a tracer displacement from x 1, y 1 a 1, b 1 to x 2, y 2 a 2, b 2 can be expressed in the form.C d is the contribution from rotational motion about the pivot. We now observe that the geometric constraint on the tracer arm during a normal tracer operation implies that. C d s, which is independent of the placement of the measuring wheel along the tracer arm, as claimed.

In Amsler’s original design for the polar planimeter see Figure 4 , the pivot joint a, b was constrained to lie on one side of the line joining the pole 0, 0 and the tracer point x, y . With this constraint, the coordinates a, b of the pivot joint are uniquely determined by the coordinates x, y of the tracer point. A Closer Look at the Compensating Polar Planimeter All authors John Eggers Published online 25 February 2020 Fig. 4 An Amsler polar planimeter. Display full size Fig. 4 An Amsler polar planimeter. Note that is the circle the planimeter traces with its pole and tracer arms fully extended and that all points accessible to the planimeter lie in . However, not all points of.This definition precludes the possibility that the pole and tracer arms would be parallel with the tracer point at an accessible point x, y . We define a set S to be accessible if the closure of S is contained in A. Thus, a simply connected domain D is accessible precisely when all points of both D and its boundary curve are accessible. Since a simple closed curve is traceable precisely when it is accessible, we will use the terminology “traceable curve” and “accessible curve” interchangeably. Accessible curves fall into one of two categories those that do not enclose the pole 0, 0 and those that do enclose 0, 0. Tracing an accessible curve C that does not enclose the pole 0, 0 results in a normal tracing operation, in which case the enclosed domain D is also accessible, as depicted in Figure 2. Curves that enclose the pole will be considered in the “The neutral circle” section. Since Green’s theorem will be used to prove that a polar planimeter actually measures the area enclosed by a simple closed curve by tracing the curve, we will state Green’s theorem here for reference. In practice, planimeters are manufactured so that positive wheel displacement corresponds to a clockwise traversal of C, but we will stay with the standard mathematical convention to avoid confusion.

Thus, if we demonstrate that. It follows that a, b satisfy the following system of partial differential equations 1 . A practical consequence of this result is that the tracer arm length T acts as a scale factor for the measuring wheel. In fact, this is how planimeters are calibrated and many of the early planimeter models had adjustablelength tracer arms so that they could be quickly adjusted to read the enclosed area using different scales. The neutral circle As we have seen, Green’s theorem cannot be applied directly to the situation where the pole 0, 0 is in the domain D. The boundary circle can be traced with the tracer arm inclined at a small fixed angle.Display full size Fig. 5 Circle centered at pole.T 2 is called the radius of the neutral circle. T 2, we see that T, R N, and P form a right triangle with hypotenuse P so that the measuring wheel’s axis is tangent to the circle and its displacement after tracing the circle is zero. T 2 for our idealized polar planimeter. However, unlike the situation where the curve C does not enclose the pole 0, 0, the measuring wheel displacement M C along C does depend on the placement of the measuring wheel along the tracer arm T when C encloses the pole 0, 0. This implies that the radius of the neutral circle R N depends on the placement of the measuring wheel along the tracer arm of the particular planimeter being used. To compute R N for a planimeter with its measuring wheel displaced a distance w from the pivot a, b along the tracer arm T, we fully extend the planimeter, as indicated in Figure 7. Note Some planimeters situate the measuring wheel on the pole side of the pivot. The computation of R N in that case is similar and left to the interested reader. A Closer Look at the Compensating Polar Planimeter All authors John Eggers Published online 25 February 2020 Fig. 7 Extended planimeter. Display full size Fig. 7 Extended planimeter.

Note how the direction the measuring wheel rolls is orthogonal to the path it traverses as the neutral circle C N is traced so that the measuring wheel displacement after tracing the neutral circle is zero. T 2, as it should. A Closer Look at the Compensating Polar Planimeter All authors John Eggers Published online 25 February 2020 Fig. 8 Geometry of neutral circle. Display full size Fig. 8 Geometry of neutral circle. In practice, most planimeter manufacturers tested each instrument they produced to determine the area of its neutral circle and included this information with the instrument, as in Figure 9. A Closer Look at the Compensating Polar Planimeter All authors John Eggers Published online 25 February 2020 Fig. 9 Area of neutral circle on data card. Display full size Fig. 9 Area of neutral circle on data card. The compensating polar planimeter In the original design of polar planimeters pioneered by Jakob Amsler, the tracer and pole arms are permanently attached by a hinged joint. This design has persisted essentially unchanged to the present day. See Figure 10. A Closer Look at the Compensating Polar Planimeter All authors John Eggers Published online 25 February 2020 Fig. 10 A Coradi compensating polar planimeter. Display full size Fig. 10 A Coradi compensating polar planimeter. In a compensating polar planimeter, the pole and tracer arms are separate pieces that fit together via a ballandsocket pivot joint; Figure 11 shows this for the planimeter used in Figure 1. This design allows the instrument to be set up in two distinct orientations with the pivot joint on either side of the line through the pole and tracer point see Figure 13 . By taking readings with each orientation of the pivot joint and averaging the results, errors caused by misalignment of the measuring wheel exactly cancel; thus, the design allows one to compensate for this type of error.

A Closer Look at the Compensating Polar Planimeter All authors John Eggers Published online 25 February 2020 Fig. 11 Parts of a compensating polar planimeter. Display full size Fig. 11 Parts of a compensating polar planimeter. Consider what happens if the compensating polar planimeter is placed in the two possible configurations. Display full size Fig. 13 Two configurations of a compensating polar planimeter. Since the two configurations are symmetric about the line connecting the pole 0, 0 and the tracer point x, y . This shows that averaging the readings of the compensating polar planimeter taken with the two configurations eliminates the error due to misalignment of the measuring wheel. The design of the compensating polar planimeter allows more precise measurement and by the 1930s the compensating polar planimeter had essentially displaced the original Amsler design. Epilogue Planimeters are fascinating instruments that deserve to be better known. Summary A polar planimeter measures the area of a region by tracing its perimeter. In this paper, we 1 show a simple approach to analyzing the operation of a polar planimeter, 2 explain what a neutral circle is and its significance, 3 explain what it is that a compensating polar planimeter compensates for, and 4 provide a glimpse of the fascinating history of this instrument. Compensating polar planimeters 1957 manual.His primary work is in undergraduate education. This may have led to his interest in juggling, making and throwing boomerangs, and collecting and playing with planimeters. To learn about our use of cookies and how you can manage your cookie settings, please see our Cookie Policy. By closing this message, you are consenting to our use of cookies. Please upgrade your browser or activate Google Chrome Frame to improve your experience. For more information, visit the Smithsonians Terms of Use page. Visit the IIIF page to learn more. Five tables of factors and settings for scale drawings or maps are provided.

Youll get the latest news, updates and more delivered directly to your inbox. You can unsubscribe at any time. A later one can be seen further down. This is the fixed scale no. 2 variety, serial number 22935, dating from c1896, in German silver, calibrated for measuring in square inches.This planimeter is adjustable to a range of metric and imperial scales. It was retailed by Dobbie McInnes, whose name is printed on the case, and it is of the special type for measuring engine indicator diagrams. By setting the adjustment such that the distance apart of the two points on the top of the instrument equals the base length of the indicator diagram, the mean effective pressure can be read directly.This adjustable planimeter was last calibrated in 1973. It is missing its checking rule The calibration slip is dated 5th October 1910. In use the top end of the arm with the maker’s name on it is placed on the centre of the large, brass weight which is knurled on its rim to rotate the white disc on which the carriage rests, presenting a smooth, matt surface for the measuring wheel to ride on. The tracing arm is graduated for a range of scales. A metric instrument obtained from Germany. Calibration details are recorded on the paper inside the lid. It was manufactured on 11th March 1954. I am indebted to Prof. Dr. Joachim Fischer of Ernst von Siemens Kunststiftung for this and other dating information for the planimeters in my collection. The calibration sheet for this one serial number 6477 is dated Sept. 1944. Unlike the one above this has a leatherette covered wooden box lined with blue velvet. It is calibrated for English units and there are several detail differences from the one above. I have also shown it assembled for use with the magnifier which can be rotated to read either the scale setting vernier or the measuring vernier. Below it is the checking bar supplied with all these instruments. It is calibrated for English units.

It is dated 1937 and its serial number is 3208. The magnifying glass for reading the vernier and the bar for checking the calibration were standard accessories.Instead of having a tracing point like the one above this one has a magnifier tracer with a fine circle in the centre. It has a foam lined case and checking rule. The arm of the planimeter has a groove in its underside, which slides along over the ball on the top of the chart centre as the tracing point is moved to follow the plot on the chart. The mechanism is essentially the same as in the Allbrit B4 but it is cased and the instrument has a silver crackle finish. Serial number 16204. An adjustable planimeter, made in Japan. It is actually a Koizumi KP 27 planimeter and dates from c1972. In addition to its case, accessories and instructions it has an outer card box. There would originally have been a rail along which it would run, being a linear planimeter as opposed to the more usual polar planimeter which all the previous ones are. It would have been used for evaluating flow rate charts. In use the arm with the knob on was moved such that the pointer on the other arm moved by a cam following a curve on a plate attached to the first arm followed the diagram.The non linear nature of the vertical ordinate can be seen on the chart on the drum. This chart records flow rates of up to 170.000 gallons per hour over a one week period. The flow rate is proportional to the square root of the pressure increase. They were used at water pumping stations to record the rate and amount of water pumped. It has a black leatherette covered, blue velvet lined, fitted case. It thus became a linear planimeter. The pole wagon depended on its weight, the accuracy of the diameter of its knurled wheels, and the lack of any play in its needle bearings to ensure that it followed an exactly straight line.

He was professor of mathematics at Zurich University, Switzerland, but lived and had his workshop founded in the end of 1854 in Schaffhausen, Switzerland. It is complete with its instructions and checking circle. A trade label on the underneath of the case shows it was retailed by W F Stanley’s Glasgow branch. Serial no.62252 dates it to the mid 1920s. It is missing the pole weight and the one shown in the left hand view is borrowed from my type 6. This has a standard tracer rather than a magnifier one. Two other versions of the Allbrit zero setting planimeter are shown further up the page and this has a similar, but larger case to that shown with the first of these. Serial number 05653. The first picture shows it stowed in its case and the second, prepared for use. The tracing arm is graduated for a range of metric and imperial scales. It is complete with pen point, pencil point and weight, container of spare leads, screwdriver, lead pusher, magnifier, and a brush. This example has clearly seen very little use, if any, as the lead container still has many unused leads in it, the pen appears not to have been used at all, and neither point fitted into the plotting arm tube until I reamed it. It is missing the handbook that would have been supplied with it. This metric version is listed in the 1958 catalogue as type A8606. It would at the same time plot the integral curve. This in turn could be traced to determine, for instance, the centre of gravity and plot the second integral curve. The process could then be repeated again to find the second moment of area also known as the moment of inertia. It dates fromI am certain it is originalIt is also basically mirror image. HoweverApart from this additional mechanism itThe arm of the planimeter has a grooveThe chart centre has. Please try again.Please try again.Please try again. Then you can start reading Kindle books on your smartphone, tablet, or computer no Kindle device required.

Register a free business account To calculate the overall star rating and percentage breakdown by star, we don’t use a simple average. Instead, our system considers things like how recent a review is and if the reviewer bought the item on Amazon. It also analyzes reviews to verify trustworthiness. Submit your article to this journal View related articles View Crossmark data This may hav e led to his interest in juggling, making and throwing boomerangs, and collecting and playing with planimeters. Although much has been written on the subject of polar planimeters, they still re main relatively obscure instruments. This is unfortunate not only do they provide a remarkably quick and precise method for measuring areas, they have a fascinating history and are a delightful example of Green’s theorem to sho w calculus students or colleagues, for that matter. Perhaps part of the reason polar planimeters are not discussed in calculus courses is that an explicit computation with the relevant v ector eld using Green’s theorem is some what complicated. There are geometric explana tions of planimeter operation that avoid Green’ s theorem, but it is debatable whether they are simpler. W e will also discuss two other important features specic to polar planimeters 1 the neutral circle, and 2 how compensating polar planimeters compensate. Figure 1 shows a compensating polar planimeter from the author’s collection that indicates ho w it is used. The pole arm merely rotates about the pole, the tracer arm is connected to the free end of the pole arm by a pivot joint a ball and socket joint in the case of the compensating polar planimeter pictured in Figure 1 , and the mea suring wheel is attached to the tracer arm with its axis parallel to the tracer arm. The area enclosed by a simple closed curved is measured by moving the tracer along the curve clockwise and recording the amount the measuring wheel moves which, as we will see, is proportional to the area enclosed by the curve.

The polar planimeter is not the only type of planimeter; there are other types of planimeters. Analysis of planimeter operation The basic design of a polar planimeter is remarkable in its simplicity as indicated above, it consists of two rigid arms connected by a piv ot joint. One arm, called the pole arm with length P, has an end xed at a point 0, 0 called the pole, about which the pole arm is free to rotate. The other arm, called the tracer arm of length T, is connected at one end to the free end of the pole arm by a pivot joint a, b that is free to rotate. At the other end of the tracer arm is the tracer point x, y which is used to trace the boundary curve C assumed to be a simple closed curve of the region D. Ho wever, the computations resulting from placing it there in our idealized planimeter will be correct since, as we will see, the dis placement M of the measuring wheel during a normal tracing operation is independent of the placement of the measuring wheel W along the tracer arm. W e dene normal tracing operation to mean that the curve is traced with the pole of the planimeter out side the region enclosed by the curve. W e will consider what happens when the pole of the planimeter is placed inside the region enclosed by the curve in the “The neutral circle” section of this paper. T o see that the total wheel displacement M during a normal tracing operation is independent of the placement of the measuring wheel, we rst observe that the dis placement of a tracer arm can be decomposed into a component perpendicular to the tracer arm and a component arising from rotation about the pivot, as indicated in Figure 3.Note that on some planimeters, the pivot is between the measuring wheel and the tracer point, in which case w would be negative. Figure 3. Decomposition of wheel motion. C d is the contribution from rotational motion about the pivot. W e no w ob serve that the geometric constraint on the tracer arm during a normal tracer operation implies that.

C ds, which is independent of the placement of the measuring wheel along the tracer arm, as claimed. In Amsler’s original design for the polar planimeter see Figure 4 , the pi vot joint a, b was constrained to lie on one side of the line joining the pole 0, 0 and the tracer VOL. 51, NO. 2, MARCH 2020 THE COLLEGE MA THEMA TICS JOURNAL 107 W e will denote by. Note that is the circle the planimeter traces with its pole and tracer arms fully extended and that all points accessible to the planimeter lie in . However, not all points of.W e dene a set S to be accessible if the closure of S is contained in A. Accessible curves fall into one of two categories those that do not enclose the pole 0, 0 and those that do enclose 0, 0 . Tracing an accessible curve C that does not enclose the pole 0, 0 results in a normal tracing operation, in which case the enclosed domain D is also accessible, as depicted in Figure 2. Since Green’s theorem will be used to prov e that a polar planimeter actually mea sures the area enclosed by a simple closed curve by tracing the curve, we will state Green’s theorem here for reference.A practical consequence of this result is that the tracer arm length T acts as a scale factor for the measuring wheel. The neutral circle As we have seen, Green’ s theorem cannot be applied directly to the situation where the pole 0, 0 is in the domain D. The boundary circle can be traced with the tracer arm inclined at a small xed angle with the radial segment from 0, 0 to the tracer point, as in Figure 5.T 2 is called the radius of the neutral circle. T 2, we see that T, R N, and P form a right triangle with hypotenuse P so that the measur ing wheel’s axis is tangent to the circle and its displacement after tracing the circle is zero. Hence the name “neutral circle.” Figure 6. Pole inside. VOL. 51, NO.

2, MARCH 2020 THE COLLEGE MA THEMA TICS JOURNAL 111 Ho wever, unlike the situation where the curve C does not enclose the pole 0, 0 , the measuring wheel displacement M C along C does depend on the placement of the measuring wheel along the tracer arm T when C encloses the pole 0, 0 . T o compute R N for a planimeter with its measuring wheel displaced a distance w from the pivot a, b along the tracer arm T, we fully extend the planimeter, as indicated in Figure 7. Note Some planimeters situate the measuring wheel on the pole side of the pivot. The computation of R N in that case is similar and left to the interested reader. Figure 7. Extended planimeter. T 2, as it should. In practice, most planimeter manufacturers tested each instrument they produced to determine the area of its neutral circle and included this information with the instru ment, as in Figure 9. The compensating polar planimeter In the original design of polar planimeters pioneered by Jakob Amsler, the tracer and pole arms are permanently attached by a hinged joint.This design allows the instrument to be set up in two distinct orientations with the pivot joint on either side of the line through the pole and tracer point see Figure 13 . By taking readings with each orientation of the pivot joint and averaging the results, errors caused by misalignment of the measuring wheel exactly cancel; thus, the design allows one to compensate for this type of error. Figure 11. Parts of a compensating polar planimeter.Since the two congurations are symmetric about the line connecting the pole 0, 0 and the tracer point x, y . This shows that av eraging the readings of the compensating polar planimeter taken with the two congurations eliminates the error due to misalignment of the measuring wheel. The design of the compensating polar planimeter allows more precise measurement and by the 1930s the compensating polar planimeter had essentially displaced the orig inal Amsler design.

In this paper, we 1 show a simple approach to analyzing the operation of a polar planimeter, 2 VOL. 51, NO. 2, MARCH 2020 THE COLLEGE MA THEMA TICS JOURNAL 115 Compensating polar planimeters 1957 manual.Vierteljahresschrift der Naturforschenden Gesellschaft in Zurich J Amsler Amsler, J. 1856. Ueber die mechanische Bestimmung des Flacheninhaltes, der statischen Momente und Vierteljahresschrift der. Naturforschenden Gesellschaft in Zurich. 4170. The Mathematics of Surveying Part II. The Planimeter B Casselman J Eggers Casselman, B., Eggers, J. 2008. The Mathematics of Surveying Part II. This document provides the mathematical fundamentals of the planimeter, that allows to measure the area of uneven or spherical flat surfaces; this instrument is important in topographic engineering. The knowledge, and the analityc foundation, of this instrument, makes the article not only of a pedagogical nature, but also it provides a historical development depicting its evolution and leading to its digital current version. View fulltext Article Fulltext available Tire Contact Footprint Area Measurement Using an Alternative Bounding Box Method August 2017 Lenko Erbakanov Liliya Staneva Ivelina Vardeva Yulian Petrov In this paper we represent an image processing technique for tire contact footprint area calculation. Two mainIn this study, a conventional experiment is combined with automated image processing to learn about the fundamentals of the hysteresis loop by measuring its area. The results of this easy and instructive experiment are substantially compatible with theory and are more precise than those obtained when using the tedious conventional method of manually evaluating the loop area. The proposed method is discussed as a clearcut and a fast tool to reproduce the results with pragmatic accuracy. Read more Chapter Cartesian and polar coordinates December 2003 JOHN BIRD Read more Discover more Last Updated 14 Jun 2020 Download citation What type of file do you want.