# Winifred Edgerton Merrill: "She Opened the Door"*

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Winifred Edgerton Merrill was the first American woman to receive a Ph.D. in mathematics. She received her degree from Columbia University in 1886 for her thesis, *Multiple Integrals (1) Their Geometrical Interpretation in Cartesian Geometry, in Trilinears and Triplanars, in Tangentials, in Quaternions, and in Modern Geometry; (2) Their Analytical Interpretations in the Theory of Equations, Using Determinants, Invariants and Covariants as Instruments in the Investigation.* This thesis presents geometrical representations of infinitesimals in several coordinate systems and uses theory involving the Jacobian to derive transformations between multiple integrals in various systems. After receiving her Ph.D. from Columbia, she continued to help women advance in a male-dominated society. She helped found Barnard College, a women's college affiliated with Columbia University, and she founded a girl's college preparatory school.[1]

## Pre-Columbia

Winifred Haring Edgerton was born in Ripon, Wisconsin, on September 24, 1862, to parents Emmet and Clara (Cooper) Edgerton [38]. The 1860 Federal Census from Fond du Lac County, Wisconsin, lists the Edgerton family farming in Wisconsin with Winifred's maternal grandparents. It also lists a boy Eber Edgerton who was eight years old [39]. Eber was not listed on later census data from the family. By the 1870 census, the family is listed as living in New York City where her father had become a real estate broker [40, 41]. Family friends included James Russell Lowell, Oliver Wendell Holmes, and Thomas Bailey Aldrich, well-known writers of the time [21]. In Winifred's son's journal, he states that Winifred was educated by private tutors. The 1870 and 1880 census lists a woman living with the family who may have been such a tutor. An enjoyment of mathematics and astronomy blossomed, and her parents had an observatory built for her in one of their New Jersey homes [21, 40, 41].


Courtesy of Wellesley College Archives.

**Figure 1. Winifred Edgerton Merrill.**

At age sixteen, Winifred decided to pursue a degree at Wellesley College, which had opened in 1875 as one of the first American colleges for women. In 1883 she graduated with honors and began teaching at Mrs. Sylvanus Reed's Boarding and Day School for Young Ladies in New York City [16, 38].

In 1883 Winifred also did independent calculations of the orbit of the Pons–Brooks comet based on data provided by the Harvard College observatory [21].[2] Winifred's interest in astronomy and her calculation on the Pons–Brooks comet soon

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* *This quote is from the legend to Columbia University's portrait of Merrill* [6].

[1] *To avoid confusion with last name changes and other family members, we will refer to Winifred Edgerton Merrill with her first name throughout most of the paper.*

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[2] *The Pons–Brooks comet was first discovered by Jean Louis Pons in 1812 and then again by accident in 1883 by*

led her to seek access to the telescope at Columbia University [8].

### Columbia University

The history of education in the United States can provide a useful context for appreciating Winifred's pioneering role. Harvard was established as the first American college in 1636, and, by the turn of the nineteenth century, twenty-two colleges for men had been established in the United States. By 1830 fifty-six colleges existed in the country. In 1836 Mount Holyoke Female Seminary began to offer women a curriculum similar to that at men's institutions. Oberlin College became the first coeducational school in 1837. By the 1880s several state universities had provisions for co-education; a number of women's colleges opened, and in 1879 Harvard Annex (later named Radcliffe) opened for women [16]. The first American Ph.D. degrees were granted by Yale in 1861 [18]. In 1877 Boston University awarded the first American Ph.D. to a woman: Helen Magill earned a doctoral degree in Greek [15].

Columbia University was originally founded in 1754 as an all-male school called King's College. In 1876 the Sorosis, New York City's leading women's club, petitioned Columbia to admit women, and in 1879 Columbia's president, Frederick Barnard, a mathematician, began to push the board for coeducation at Columbia. Resistance came from board members who felt that women would be too frail and inferior to handle the rigorous academics. Some feared that the male students would be distracted or that, because of New York City's high population and parents' desire to keep daughters close to home, Columbia could be taken over by women. The board rejected coeducation at Columbia, but in 1883 they struck a compromise: Women would be barred from attending courses, but they would be given detailed syllabi and they would take exams. If the necessary exams were passed, the women would be awarded the appropriate degrees [12, 27].

At this time, women who did earn bachelor's degrees typically began teaching. After the Civil War, there was a demand for teachers and, financially, it was beneficial to hire women since they were only paid about one-third the salary of men [38].

It was in this setting that Winifred began her quest to continue her education at Columbia. Melvil Dewey, the former librarian at Wellesley and Columbia's librarian-in-chief, introduced her to President Barnard [12]. On January 5, 1884, and with Barnard's backing, she petitioned Columbia University for use of the school's telescope [8, 12]. Initially, her petition was rejected, but she was encouraged by President Barnard to personally meet with each member of the Board of Trustees. Reverend Morgan Dix, Dean of Students and a member of the Board, was a vocal opponent to women in higher education. However, Winifred was able to win him over, and he eventually became a friend and strong advocate for her [12, 21]. On February 4, 1884, the members of the Board of Trustees gave Winifred permission to use the school's telescope, and she was assigned to study astronomy and mathematics under Professor John Rees. The members of the board considered her to be an "exceptional case". The Board of Trustees decided that, since she wasn't specifically seeking admission to Columbia, and as there wasn't another facility in New York City where she could access a telescope, they would allow her to use the instruments at Columbia. Additionally, they considered the work she had done calculating the orbit of the Pons–Brooks comet and deemed her to be proficient in the subject matter. As part of her conditions to study, she was told "not to disturb the male students". She also was required to serve as a laboratory assistant to the director of the observatory [10]. This meant, in part, that she was to clean and care for the instruments in the laboratory [38].

Winifred's struggle to receive permission to use the telescope at Columbia was not her last hurdle. For, although she was not the first woman to attend classes at Columbia, it was then frowned upon for women to attend lectures. As a result, most women studied alone from the course text. In one of Winifred's courses, some men in the class asked the professor to choose one of the hardest textbooks of the time with hopes that she would fail since she would not be able to attend the lectures. This attempt backfired since she had already studied that text at Wellesley [38].

Another challenge she faced during her time at Columbia was the amount of time she spent in solitude. She was not supposed to interact much with the male students, she put in late hours of private study using the telescope, and she spent many hours cleaning and caring for instruments. However, like the other challenges she had faced, she found a way to overcome the loneliness. In her 1944 interview, she talked of her time alone in the observatory: "I had a great chest and in that chest I had twenty dolls. I was up there a great deal. I used to take them out… If I heard anyone coming I would sweep them into the chest" [17]. She later told her son that she brought the dolls out to keep her company [21]. When asked in the same

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*William Brooks. Based on the 1812 appearance, German astronomer Johann Encke worked to calculate the comet's orbit and period, which was found to be about seventy years* [30].

interview if her parents supported her work, she answered, "In everything. Anything I wanted to do was all right. They apparently had confidence in me; I don't see how they did. I was up there until 2 o'clock alone in that laboratory at night. Today, if it were my daughter, I would be on pins and needles" [17].

On June 7, 1886, just two-and-a-half years after Winifred entered Columbia, she completed her thesis. At the Board of Trustees meeting that day the following motion was made and passed unanimously: "That in consideration of the extraordinary excellence of the scientific work done by Miss Winifred Edgerton, as attested by the Professors who have had the superintendence of her course in practical Astronomy, and the Pure Mathematics in the Graduate Department, the degree of Doctor of Philosophy can be conferred upon Miss Edgerton cum laude" [8, 11].[3] Winifred Edgerton thus became the first American woman to receive her Ph.D. in mathematics and the first woman to graduate from Columbia University [12, 38]. The New York times reported the event: "... Nothing unusual occurred until Miss Winifred Edgerton, A.B., Wellesley College, came to the stage to accept her degree of Doctor of Philosophy, *cum laude*. She was greeted with a terrific round of applause which the gallant students in the body of the house kept up for fully two minutes. She was modestly dressed in a walking dress of dark brown stuff, trimmed with velvet of the same material, and wore a brown chip hat which had a pompon of white lace and feathers. She bore herself modestly and well in the face of the applause of the Professors and Trustees on the stage, and the slight flush on her face was perceptible only to those quite near her. When, with the coveted parchment, she turned to leave the stage, a huge basket and two bouquets were passed up to her. The half dozen young men who had received parchment with her seemed to have lost their sense of courtesy and politeness in spite of their titles, and did not offer to assist her. She would have been obliged to carry them from the stage had not the white-haired Professor Drisler hastened to her assistance and relieved her of her floral burden. Hearty applause and a Columbia cheer greeted this act of courtesy" [9].[4]

[3] *At the June 7, 1886, meeting of the Columbia Trustees, they also decided to admit women on equal footing as men, although no specific provisions as to whether or not women would study in the same classrooms were made* [7].

[4] *Winifred Edgerton was not the first American woman to earn her Ph.D. in mathematics. That honor goes to Christine Ladd Franklin, who earned her Ph.D. in mathematics in 1882 from Johns Hopkins University. Her work was published in 1883, but because she was a woman, Johns Hopkins did not award the degree until 1926* [14].

## Thesis

Winifred's 1886 doctoral thesis is titled *Multiple Integrals (1) Their Geometrical Interpretation in Cartesian Geometry, in Trilinears and Triplanars, in Tangentials, in Quaternions, and in Modern Geometry; (2) Their Analytical Interpretations in the Theory of Equations, Using Determinants, Invariants and Covariants as Instruments in the Investigation* [22]. In a 1937 interview, she noted her dissertation's two parts, the first in mathematical astronomy, which included the orbit computation of the 1883 comet, and a second in pure mathematics [15]. And, although her official thesis on record at Columbia is in mathematics, she referred to it in a 1944 interview with Mr. Howson, as "... two practically, one for pure mathematics and one for astronomy..." [17].

A major part of this thesis explored infinitesimals in various systems from analytical geometry. The systems considered were Cartesian, oblique, polar, trilinear, triplanar, tangential, and quaternions. Winifred began by using a geometric approach to find the infinitesimals for length, area, and volume for these various systems. She stated that the presentation of the trilinear and triplanar coordinate systems was new. Then she presented the transformation method abridged from Bartholomew Price's differential and integral calculus book for transformation of multiple integrals from one system to another [26]. Part of her original work thus included using this method for transformations from the Cartesian system to that of triplanars and tangential coordinates. She then examined the infinitesimals for area and volume obtained by the geometric approach and the analytical method for various systems and showed their equivalence. In addition, new work was done with transformations and the quaternion system [22].

In her thesis, Winifred beautifully sketched and explained the infinitesimals for length, area, and volume for the various coordinate systems listed above. When working with the oblique system (see Figure 2), where $\theta$ is the angle between the $X$ and $Y$-axis, and $\theta'$ is the angle between $Z$-axis and the $XY$-plane, she showed that the infinitesimal for volume is $\sin(\theta)\sin(\theta')dX\,dY\,dZ$. As our Figure 3 (her Figure 5) shows, she examined the Triplanar System, where the coordinates for a point are determined by three intersecting planes. Distances $\alpha, \beta, \gamma$ determine the perpendicular Distances a point is from planes $OBC$, $OAC$, and $OAB$, respectively. Winifred related this system to the oblique system by letting $\phi$ be the angle between the normals to planes $OAC$ and $OBD$ and letting $\phi'$ be the angle between the plane containing the last two normals with the normal to the plane $OAB$. With this idea, the infinitesimal for volume was

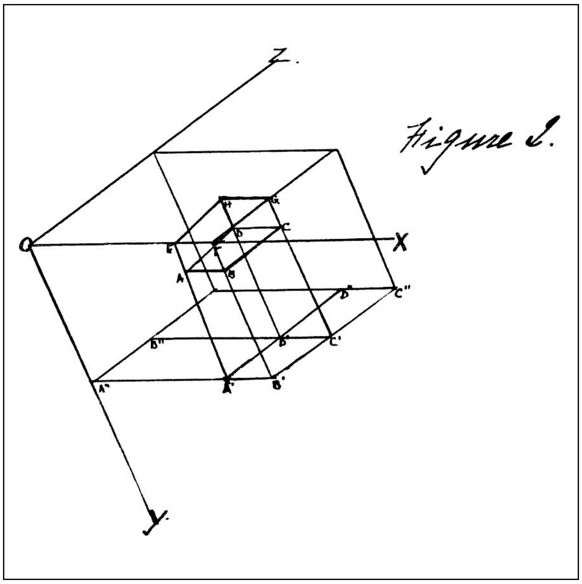




**Figure 2. This thesis figure illustrates the geometry of the infinitesimal for volume in the oblique system.**

found to be $\sin(\phi)\sin(\phi')d\alpha\, d\beta\, d\gamma$, similar to that for the oblique system.

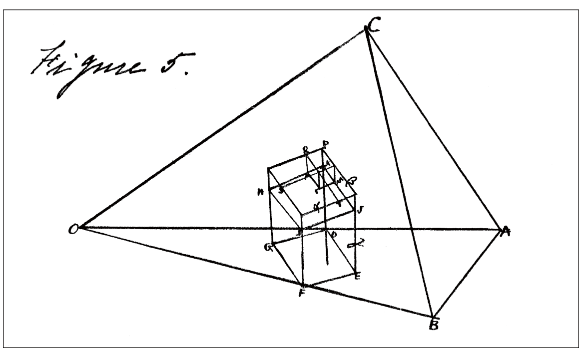




**Figure 3. This thesis figure illustrates the geometry of the infinitesimal for volume in the triplanar system.**

Winifred next presented a method from Price's book to transform integrals from one coordinate system to another. In Price's text, he first illustrated the idea with the special case of transforming a double integral in the Cartesian coordinates $x$ and $y$ to the polar coordinates $r$ and $\theta$. The two systems are related by

$$x = r\cos\theta \quad \text{and} \quad y = r\sin\theta.$$

The differentials are then

$$dx = \cos(\theta)dr - r\sin(\theta)d\theta$$

and

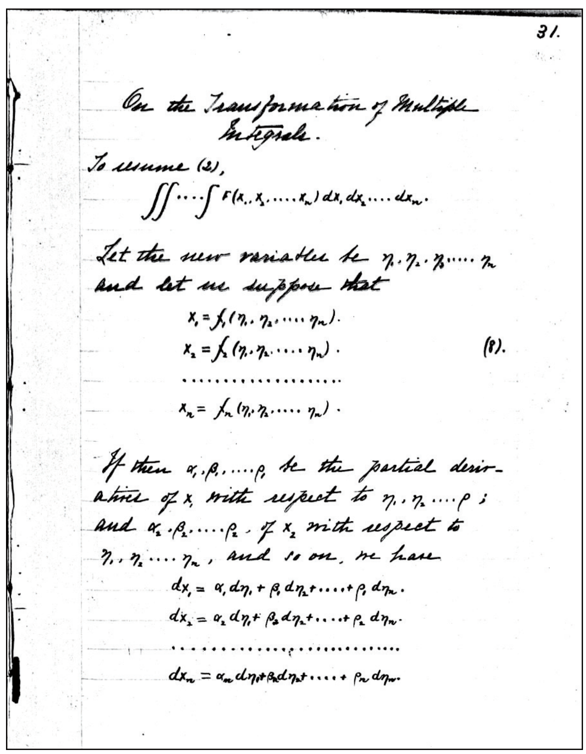
$$dy = \sin(\theta)dr + r\cos(\theta)d\theta.$$

In the integral in the Cartesian system, $x$ is held constant when integrating with respect to $y$. Thus, in the $y$-integral, one can consider

$$dx = 0 = \cos(\theta)dr - r\sin(\theta)d\theta.$$

This equation can be solved for $dr$ and substituted into the expression for $dy$ to yield $dy = \frac{r}{\cos(\theta)}d\theta$. This changes $dx\ dy$ to $\frac{r}{\cos(\theta)}dx\ d\theta$. With the same argument, $\theta$ can now be considered constant in an integral with $x$, and thus, $dx$ becomes simply $\cos(\theta)dr$. This argument shows that $dx\ dy$ changes to $r\ dr\ d\theta$ in the transformation from the Cartesian system to the polar system [26].

Winifred presented the material from Price's book which generalizes this idea for a transformation from one $n$-dimensional system in $x_1, x_2, \ldots, x_n$ to a different $n$-dimensional system in $\eta_1, \eta_2, \ldots, \eta_n$. Similar to the relations between Cartesian and polar coordinates, equation array (8) of the thesis relates $x_1, x_2, \ldots, x_n$ in terms of $\eta_1, \eta_2, \ldots, \eta_n$ (see Figure 4). She thus obtained equations for the differentials of $x_1, x_2, \ldots, x_n$ in terms of the differentials of $\eta_1, \eta_2, \ldots, \eta_n$.


31.

On the Transformation of Multiple Integrals.

To resume (2),

$$\iint\cdots\int F(x_1, x_2, \ldots, x_n)\,dx_1\,dx_2 \ldots dx_n.$$

Let the new variables be $\eta_1, \eta_2, \eta_3, \ldots \eta_n$ and let us suppose that

$$x_1 = f_1(\eta_1, \eta_2, \ldots \eta_n).$$
$$x_2 = f_2(\eta_1, \eta_2, \ldots \eta_n). \qquad (8).$$
$$\ldots\ldots\ldots\ldots$$
$$x_n = f_n(\eta_1, \eta_2, \ldots \eta_n).$$

If then $\alpha_1, \beta_1, \ldots \rho_1$ be the partial derivative of $x_1$ with respect to $\eta_1, \eta_2 \ldots \rho$; and $\alpha_2, \beta_2, \ldots \rho_2$, of $x_2$ with respect to $\eta_1, \eta_2 \ldots \eta_n$, and so on, we have

$$dx_1 = \alpha_1 d\eta_1 + \beta_1 d\eta_2 + \ldots + \rho_1 d\eta_n.$$
$$dx_2 = \alpha_2 d\eta_1 + \beta_2 d\eta_2 + \ldots + \rho_2 d\eta_n.$$
$$\ldots\ldots\ldots\ldots$$
$$dx_n = \alpha_n d\eta_1 + \beta_n d\eta_2 + \ldots + \rho_n d\eta_n.$$



**Figure 4. Page 31 of Winifred Edgerton's thesis.**

Again, as was done in the Cartesian to polar transformation above, when dealing with an integral in $x_1$, one can consider $x_2, \ldots, x_n$ to all be constant, and thus expressions for $dx_2, \ldots, dx_n$ would all be zero when considering $x_1$. This gives equation array (10) of the thesis (see Figure 5).

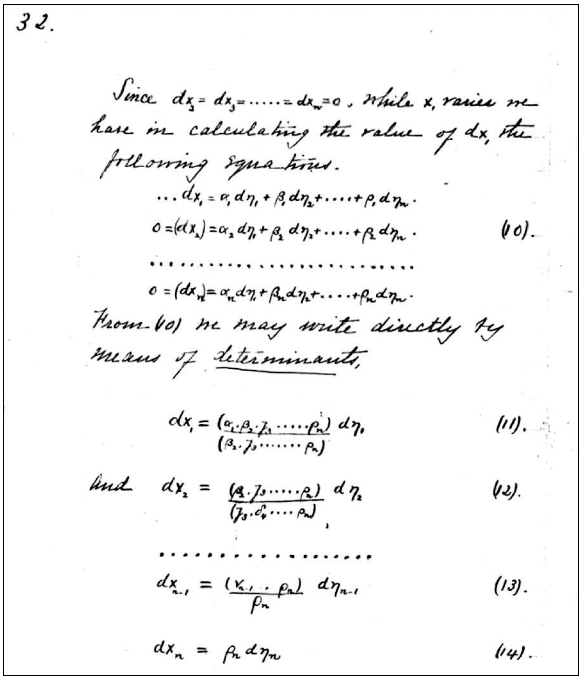





Figure 5. Page 32 of thesis.

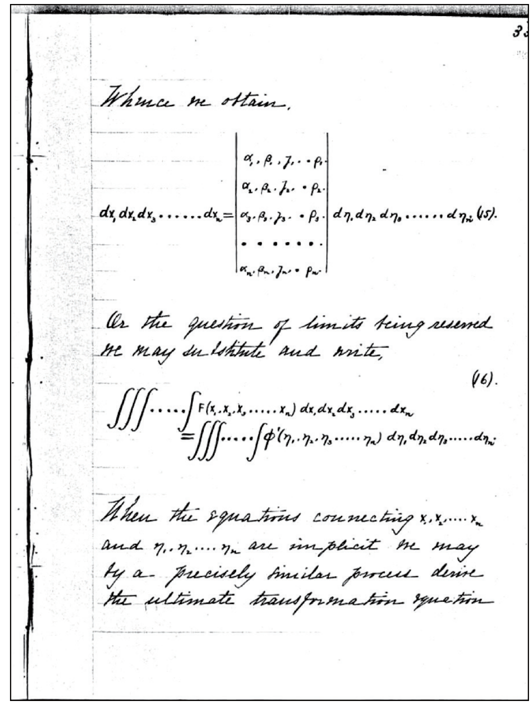





Figure 6. Page 33 of Winifred Edgerton's thesis.

Price cited Peacock's *A Treatise on Algebra* for a solution to this system of equations. He also cited a paper by Boole for the method demonstrated for transformations of multiple integrals [5, 25, 26]. When completing this work, one obtains thesis equation (15) (see Figure 6).

$$dx_1\, dx_2\, \cdots dx_n = \begin{vmatrix} \alpha_1 & \beta_1 & \cdots & \rho_1 \\ \alpha_2 & \beta_2 & \cdots & \rho_2 \\ \cdots & \cdots & \cdots & \cdots \\ \alpha_n & \beta_n & \cdots & \rho_n \end{vmatrix} d\eta_1\, d\eta_2\, \cdots d\eta_n.$$

Here $\alpha_1, \beta_1, \dots, \rho_1$ are the partial derivatives of $x_1$ for $\eta_1, \eta_2, \dots, \eta_n$, respectively, $\alpha_2, \beta_2, \dots, \rho_2$ are the partial derivatives of $x_2$ for $\eta_1, \eta_2, \dots, \eta_n$, respectively, and the pattern continues.

Following Winifred's presentation of the transformation method, she demonstrated its application with transformations among several systems. She used this method to pass from the Cartesian system to the oblique system. She next used that work to pass from the Cartesian to the trilinear and triplanar systems. This last work with trilinear and triplanar systems, as stated earlier, was one of the new results in her thesis. This work involved obtaining relations between the Cartesian and oblique systems and the oblique and triplanar systems to obtain the needed equation arrays for the Cartesian and triplanar systems [22].

Finally, she presented the area and volume infinitesimal elements from the geometric and analytical techniques for the various systems discussed in her thesis. For some systems, such as the triplanars, the written forms varied, depending on the equations she used to do the analytical work. She then went on to show that the corresponding forms from both the geometrical and analytical methods were equivalent [22]. Her thesis continued with applications to quaternions and various other issues. This paper presents what the authors believed would be of most interest to the majority of readers.

### Post Columbia

After her graduation, Winifred continued teaching at Mrs. Sylvanus Reed's School, where she became the vice principal [15, 38]. She was offered a professorship position at Wellesley, but she declined the offer to preserve a more traditional role.[5] In May of 1887, she wrote to Morgan Dix about her decision, saying that "this life which now opens before me is brighter than the stars". In September of 1887, she married Frederick Merrill, a graduate of Columbia's School of Mines [12, 21].

Having proven herself at Columbia, Winifred Edgerton Merrill was invited in 1888 to serve on a five-member committee to found Barnard College,

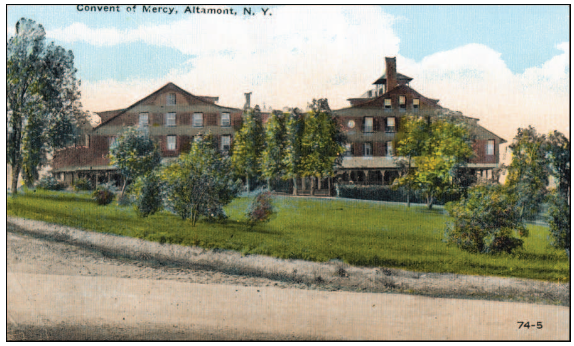
[5]*Wellesley is referred to in several published references, but it should be noted that, in her son Hamilton's journal, he transcribed a letter his mother wrote to Morgan Dix on May 29, 1887, which refers to "declining the position in Northampton (Smith)"* [21].

which was to be an affiliate of Columbia specifically for women. She worked on drafting the proposal for the new college, but later resigned from the committee [12]. In her 1944 interview she stated, "We had our meetings in downtown. My husband objected very much. He thought it was entirely improper for me to go to a man's office downtown. I had to resign from the Committee" [17].

Frederick Merrill completed his Ph.D. with honors at Columbia in 1890 [1]. In October of that year, Frederick Merrill was appointed as assistant state geologist of New York. Frederick and Winifred and their first child, Louise (born June 3, 1888), then moved to Albany, where their first son, Hamilton, was born on December 21, 1890. In that same month, Frederick was appointed assistant director of the New York State Museum, where he became the director in 1894.[6] A second daughter, Winifred, was born on July 21, 1897, and a second son, Edgerton was born April 21, 1901 [21]. In Albany, Winifred was invited to serve on the school board. In regards to this invitation, Winifred stated, "My husband did not speak to me for two days. He was born in New York and had these ideas of what was proper for women to do" [17].

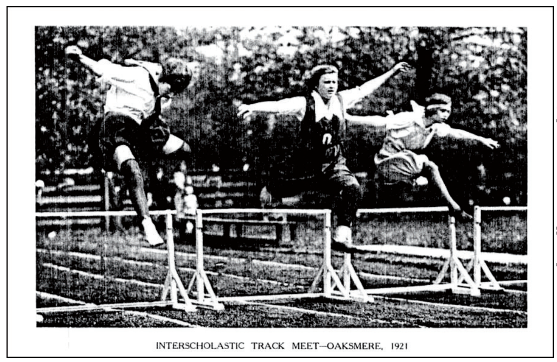
The Merrills valued both intellect and social prominence. They entertained many well-known guests. One of Winifred's favorite guests was educator Booker T. Washington, founder of Tuskegee Institute [21].[7] They traveled for work related to Frederick's position, although Winifred traveled less as their family grew.

The Merrills' social standing was greatly aided by two large inheritances. Frederick's mother and an uncle each bequeathed $100,000 to the Merrills. To put this into perspective, as the state geologist, Frederick annually earned $3,500 [21]. At this same time, the average annual salary for the country was under $500 [35]. Hamilton wrote that it was evident his family had money because each time the family moved, they moved to a more prestigious residence with more hired help. The finest of these homes was the King Mansion on Washington Avenue in Albany. The three-story brownstone even included a bowling alley. In 1894 the family also purchased a 360-acre farm in Altamont, New York, where they would summer. Their home there was the former Kushaqua Hotel, a large Victorian structure [20, 21]. During this time, Hamilton wrote of the family's most famous acquaintances, Teddy Roosevelt and his family, and how the two families' children became familiar playmates. He wrote of an amusing story: "At Altamont we were occasionally visited by the Roosevelts who were all great outdoor enthusiasts and came hiking out our way during the summer. One day, I remember, both Mother and Louise were down with the mumps when Father and I spotted the entire Roosevelt tribe, led by Teddy himself, marching up the road on a hike. We ran downstairs and shooed the Governor and his family away without so much as a Hello" [21].



Postcard from the Archives of the La Salette Missionaries, 85 New Park Ave., Hartford CT.

**Figure 7. Summer home of the Merrills[8] and former Kushaqua Hotel. (In 1924, the property was purchased by the La Salette Missionaries. The mansion burned in 1946 [20]).**



Mamaroneck Village Historical Society.

**Figure 8. Page 49 of the 1921–1922 Oaksmere courses book.**

In 1902, only one year after the birth of Winifred and Frederick Merrill's fourth child, the family began having financial difficulties. Hamilton Merrill blamed his mother for throwing "lavish parties, spending frivolously, and making bad investments". These financial difficulties led to bankruptcy. Bankruptcy laws of the time required that Frederick Merrill resign his position as state geologist. The financial difficulties also led to the Merrills separating in 1904. Hamilton Merrill noted

[6] *Frederick Merrill directed New York State's scientific exhibits at the 1893 Chicago World's Fair and the 1904 St. Louis World's Fair* [36].

[7] *Tuskegee Normal School was founded on July 4, 1881, as an institution for African American students. Booker T. Washington, a former slave, was their first teacher and was the principal of the school until his death in 1915* [33].

[8] *The summer mansion of the Merrills came later.*

Lucile Godbold Papers, J. Drake Edens Library Archives, Columbia College.

**Figure 9. 1922 U.S. Women's Track Team.**

that his mother was a "brilliant, forceful woman with greatness in her. She had a tremendous inner urge. After she gave up her career for her family, this urge found an outlet in four children and intense social activities" [21].

After their separation, Frederick Merrill moved west for work. He stayed in contact with his family and died in 1916. Winifred became the principal at Anne Brown's School for Girls in New York City and attempted to furnish and rent apartments [21].

In 1906 she founded Oaksmere School for Girls in New Rochelle, New York, which was also known as Mrs. Merrill's School. She had no capital of her own to begin a school; however, she was able to assemble many men of means as benefactors. Oaksmere, a college preparatory school, offered a variety of courses and catered to patrons who could freely spend; its tuition in 1921 was $2,400 with an additional cost of $215 for uniforms. In 1914 the school was relocated to Mamaroneck, New York [21, 24].

Due to Oaksmere's success in New York, a Paris branch opened in 1921 [24].[9] Both schools thrived for some time before financial difficulties were encountered. Winifred was once again responsible for spending lavishly. For example, during the construction of a swimming pool, nearly $10,000 was raised but approximately $30,000 was spent. As a result of these financial difficulties, Oaksmere was forced to close in 1928 [21].

Some of the lavish spending for high quality facilities may have been carried out to maximize women's abilities to participate fully in athletics. The Mamaroneck campus had a variety of athletic facilities, including a large outdoor track and an indoor swimming pool [24]. When the first international track meet for women was held in Paris in 1922, some Oaksmere girls participated. Winifred helped sponsor the American team and served as a chaperone [32, 34]. The girls that attended Oaksmere had the opportunity to participate in track meets from 1921 through 1924 [31].

In addition to work in education, Winifred continued her scholarly work, publishing a book titled *Musical Autograms* with her future son-in-law Robert Russell Bennett, who later became an Oscar- and Emmy-award-winning composer and orchestrator. In the book they examined musical qualities in the signatures of famous people of her time. Bennett describes his first meeting with Winifred and the start of their work: "...Mrs. Winifred Edgerton Merrill needed a composer to help her work something out musically,... she asked me to take home a few pages of black dots spread out over musical staves and see what they suggested to me. Completely in the dark, I made notes out of all the black dots, chose certain things arbitrarily...". He went on to describe the created composition: "The only noticeable characteristic ... its tendency to sound Slavic in some spots." At a later meeting, Winifred told him she had taken the words *Russian National Anthem* written in Russian and translated them mathematically. Bennett wrote how Winifred would take words written on a music staff or place a staff over words. He stated, "... the black dots being at every dot or intersection of lines, one at each extremity of a straight line and three to express every simple curve". In their book, they studied the musical qualities of the signatures of twenty famous men of the time, including then-president Wilson, ex-presidents Taft and Roosevelt, and John Philip Sousa. Bennett wrote of Winifred, "It was her hope that a person's signature, written across a musical staff, would furnish a melodic line expressive of that person's character, and possibly his or her mood at the time of signing" [4] Five of these autograms have been performed and made available on the Web by pianist Phillip Sear [29].

Winifred was also involved in politics. She spoke publicly against prohibition in the campaign to repeal the Eighteenth Amendment [13].

In 1933 Columbia honored Winifred in a ceremony attended by more than 200 guests. The school hung her portrait within Philosophy Hall. The portrait, a joint gift of the Wellesley class of 1883 and the Columbia Women's Graduate Club, bears the legend "She Opened the Door" [6].

From 1928 through 1948, Winifred was the librarian at the Barbizon Hotel in New York City [12, 21]. This was a twenty-three-story hotel established in the 1920s to provide women a safe residential option when leaving home to seek

[9] *Prior to the Paris school, Winifred and Oaksmere also funded a Paris ambulance during World War I* [37].

Art Properties Office at Columbia.

**Figure 10. Portrait of Winifred Edgerton Merrill.**

professional careers [3]. She died in Fairfield, Connecticut, on September 6, 1951, at age eighty-eight [23].

Beaulah Amidon wrote in the *New York Times*, "Several years ago, . . . I had the privilege of a long conversation with Mrs. Merrill. . . . Though almost eighty years of age at the time, her eyes were on the future, and she was much more interested in the progress of women in business and the professions than in the old battle for their higher education, in which she played so notable a part." [2]

## Conclusion

Winifred Edgerton Merrill pioneered a way for women to continue their education. Instead of losing hope when Columbia initially denied her access to the school's telescope, she patiently petitioned for it again. She became the first American woman to receive her Ph.D. in mathematics and helped give other women the chance to earn and receive degrees as well. She raised a family, and continued to help open doors to women by opening college preparatory schools for girls. These schools gave young women a background in a variety of academic areas as well as the opportunity to pursue athletics. Winifred Merrill helped women emerge and become more active in the male-dominated society in which she lived.

The authors would like to recognize the work of Judy Green and Jeanne LaDuke and the publication of their book, *Pioneering Women in American Mathematics: The Pre-1940 PhD's* [15]. The authors did most of their research prior to the publication of this book [19], but found it a wonderful reference when adding some final touches for this publication. Supplementary material to the book can be found on the American Mathematical Society hosted site `http://www.ams.org/publications/authors/books/postpub/hmath-34-PioneeringWomen.pdf`.

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Susan Kelly dedicates this paper to her two sons, Kyle and Ryan.

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