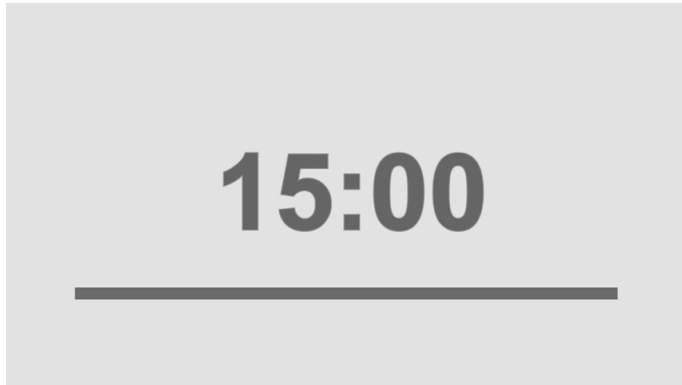


As you are coming in...

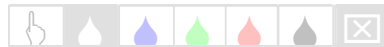
Start with review worksheet

- Grab a name tag and write your name on it please.
- Get to a board and start working.



A reminder on how to read tables of Clebsch-Gordan Coefficients

$j_1 \otimes j_2$	J M	J M
m_1 m_1 ...	m_2 m_2 ...	Coefficients with implied $\sqrt{\quad}$
	J M	J M
	m_1 m_1 ...	m_2 m_2 ...
		Coefficients with implied $\sqrt{\quad}$



Symmetries!

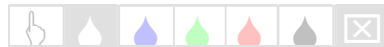
Physics 564
Dr. Toggerson



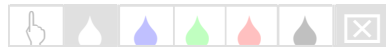
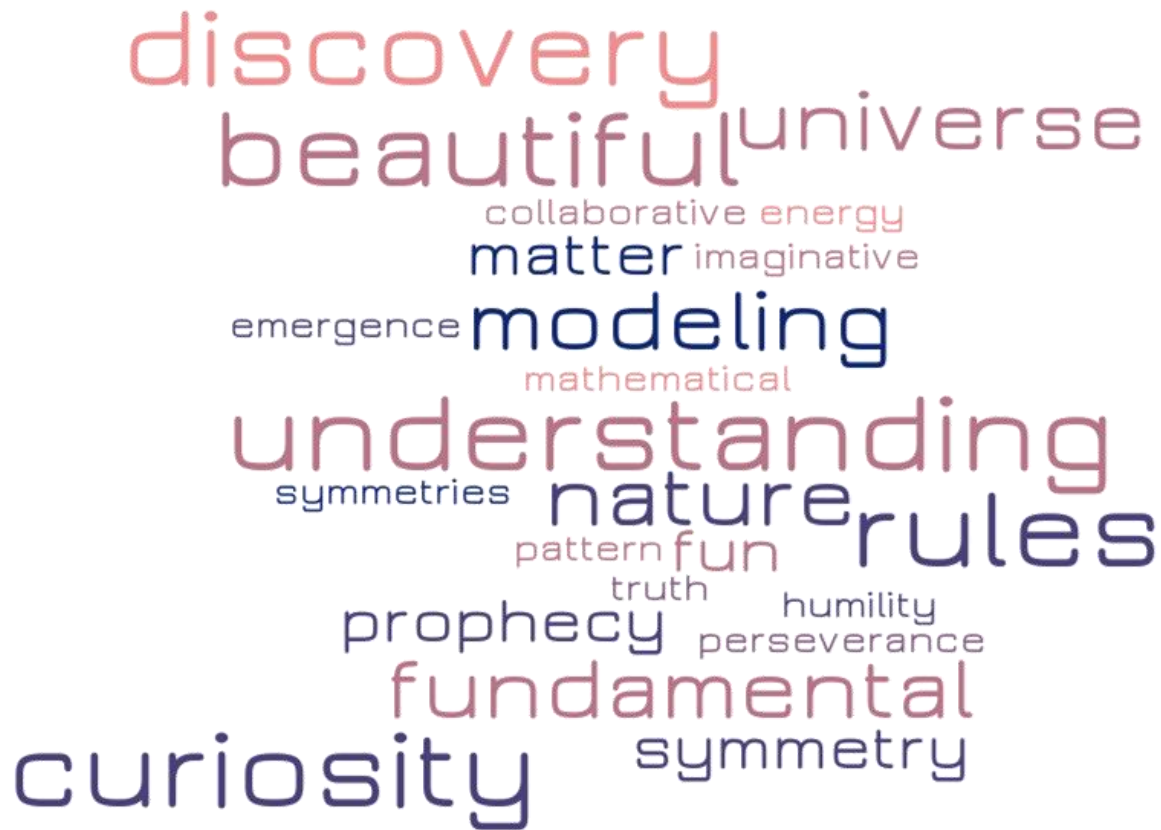
First, a Note About Sources

For this discussion, and the subsequent related discussion of group theory, I am pulling from the following sources:

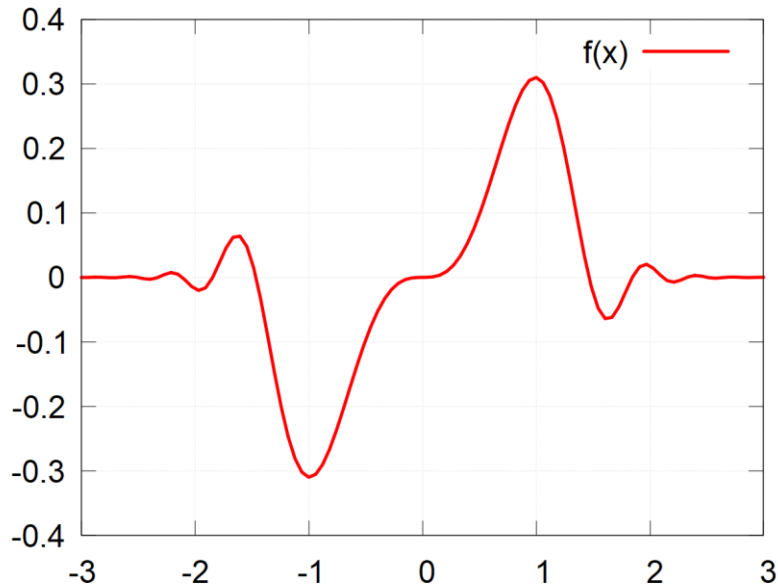
- D. J. Griffiths and D. F. Schroeter, *Introduction to Quantum Mechanics*, Third edition (Cambridge University Press, Cambridge ; New York, NY, 2018). Chapter 6.
- D. J. Griffiths, *Introduction to Elementary Particles* (J. Wiley and sons, New York Chichester Brisbane [Etc.], 1987). Chapter 4.
- J. Mathews and R. L. Walker, *Mathematical Methods of Physics*, 2d ed (W. A. Benjamin, New York, 1970). Chapter 16.
- S. T. Thornton and J. B. Marion, *Classical Dynamics of Particles and Systems*, 5. ed., international student ed., [Nachdr.] (Thomson, Brooks-Cole, Belmont, Calif., 2008). Chapter 7.



I asked the faculty and graduate students for one word which encapsulates *physics*



Start by Reviewing *Mathematical Symmetries*



How are the following related?

■ $[f(-x)]^6$? $[f(x)]^6$

■ $\left. \frac{\partial f}{\partial x} \right|_{+2}$? $\left. \frac{\partial f}{\partial x} \right|_{-2}$

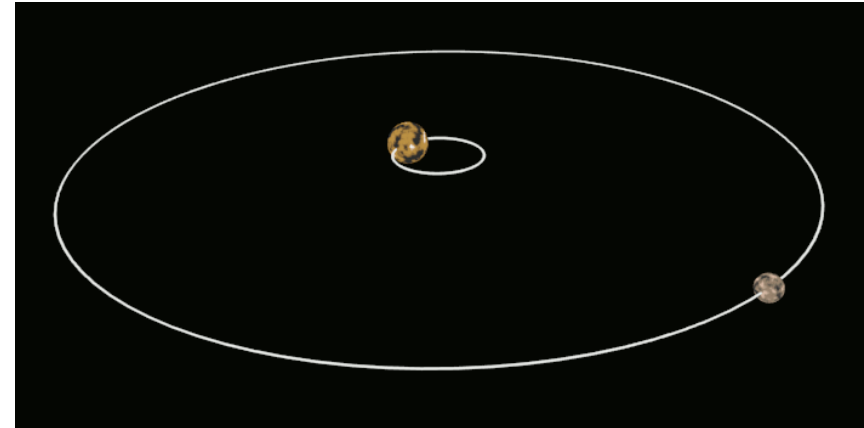
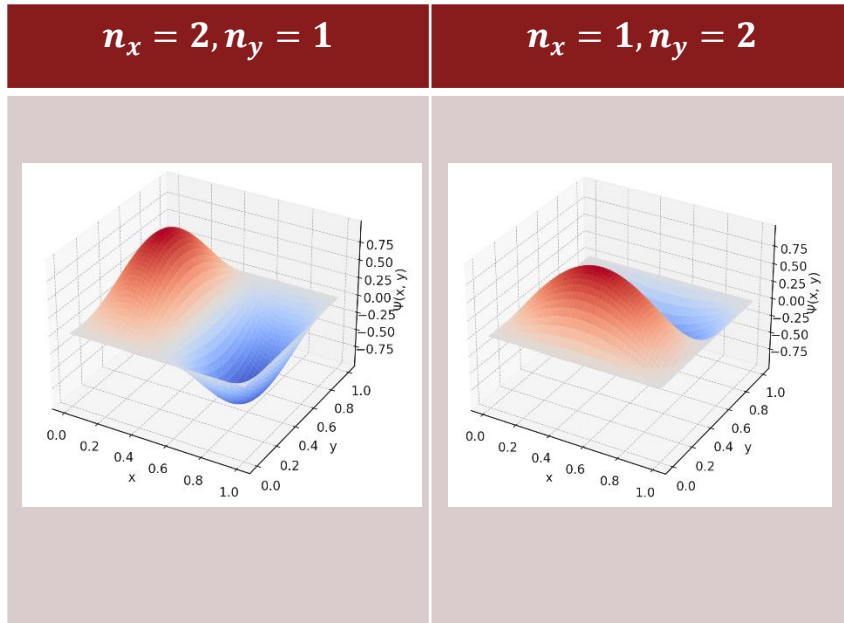
■ $\int_{-3}^3 f(x) dx = ?$

Give me a symmetry

Symmetries in Physics – Often the Reverse: We Find A Neat Pattern...

The first excited states of a particle in a 2-D box are degenerate

Planets return to the same spot each “year”

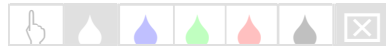


These Are Found To Be Due To Some *Underlying* Symmetry

Noether's Theorem



For any conserved current j_μ | $\partial_\mu j^\mu = 0$ there exists a conserved scalar $Q = \int d^3x j_0$.



Einstein's Obit of Noether

To the Editor of The New York Times:

The efforts of most human-beings are consumed in the struggle for their daily bread, but most of those who are, either through fortune or some special gift, relieved of this struggle are largely absorbed in further improving their worldly lot. Beneath the effort directed toward the accumulation of worldly goods lies all too frequently the illusion that this is the most substantial and desirable end to be achieved; but there is, fortunately, a minority composed of those who recognize early in their lives that the most beautiful and satisfying experiences open to humankind are not derived from the outside, but are bound up with the development of the individual's own feeling, thinking and acting. The genuine artists, investigators and thinkers have always been persons of this kind. However inconspicuously the life of these individuals runs its course, none the less the fruits of their endeavors are the most valuable contributions which one generation can make to its successors.

Within the past few days a distinguished mathematician, Professor Emmy Noether, formerly connected with the University of Göttingen and for the past two years at Bryn Mawr College, died in her fifty-third year. In the judgment of the most competent living mathematicians, Fräulein Noether was the most significant creative mathematical genius thus far produced since the higher education of women began. In the realm of algebra, in which the most gifted mathematicians have been busy for centuries, she discovered methods which have proved of enormous importance in the development of the present-day younger generation of mathematicians. Pure mathematics is, in its way, the poetry of logical ideas. One seeks the most general ideas of operation which will bring together in simple, logical and unified form the largest possible circle of formal relationships. In this effort toward logical beauty spiritual formulas are discovered necessary for the deeper penetration into the laws of nature.

Born in a Jewish family distinguished for the love of learning, Emmy Noether, who, in spite of the efforts of the great Göttingen mathematician, Hilbert, never reached the academic standing due her in her own country, none the less surrounded herself with a group of students and investigators at Göttingen, who have already become distinguished as teachers and investigators. Her unselfish, significant work over a period of many years was rewarded by the new rulers of Germany with a dismissal, which cost her the means of maintaining her simple life and the opportunity to carry on her mathematical studies. Farsighted friends of science in this country were fortunately able to make such arrangements at Bryn Mawr College and at Princeton that she found in America up to the day of her death not only colleagues who esteemed her friendship but grateful pupils whose enthusiasm made her last years the happiest and perhaps the most fruitful of her entire career.

ALBERT EINSTEIN.
Princeton University, May 1, 1935.

[New York Times May 4, 1935]

