Welcome back to PHY 3305

Today's Lecture:

Expectation Values

Max Born

1882 - 1970

He is the one who figured out $P(x) = \psi^*\psi$ and got the 1954 Nobel prize for it.

Professor Jodi Cooley

ANNOUNCEMENTS

- Reading Assignment for Tuesday, Oct 31: Chapter 6.1 - 6.4.
- Problem set 10 is due Tuesday, Oct 31 at 12:30 pm.
- Regrade for problem set 9 is due Oct 31 at 12:30 pm.
- Next week, first drafts of your presentations are due. They should be emailed to Dr. Cooley <cooley@physics.smu.edu> in pdf format before 12:30 pm on Tuesday, Oct 31.
- Dark Matter Days at SMU: Series of events — stay up-to-date: https://www.physics.smu.edu/web/events/darkmatterday/

Oct. 29 at 4pm in McCord Auditorium:

DARK MATTER DAY

Marusa Bradac, Associate Professor at UC Davis, will give a public lecture on Dark Matter. Reception to follow lecture from 5-6 pm in the Dallas Hall Rotunda with beverages and light snacks.

Free and open to the public.

smu.edu/physics

Please RSVP by October 27.
smudarkmatterlecture.eventbrite.com

https://www.physics.smu.edu/web/events/darkmatterday/

October 31 Dark Matter Rock Hunt

9am-4pm on the SMU Campus

DARK MATTER DAY

The Department of Physics has hidden "Dark Matter Rocks" all across the SMU campus—find a dark matter rock, bring it to FOSC 102, and get a special prize.

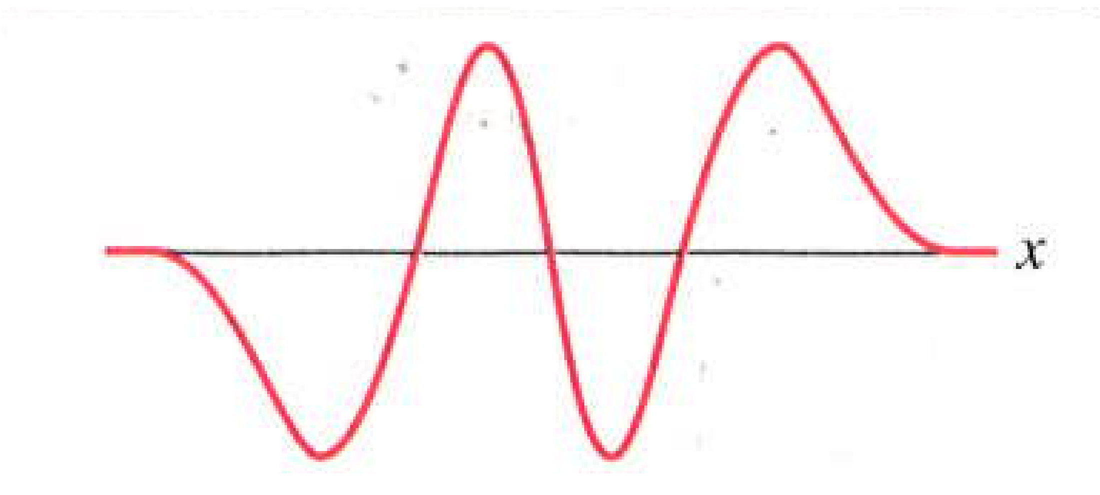
smu.edu/physics

All SMU students, faculty, staff and community members are welcome to join in the search.

Follow us on twitter @SMUPhysics for clues to dark matter rock locations throughout the day!

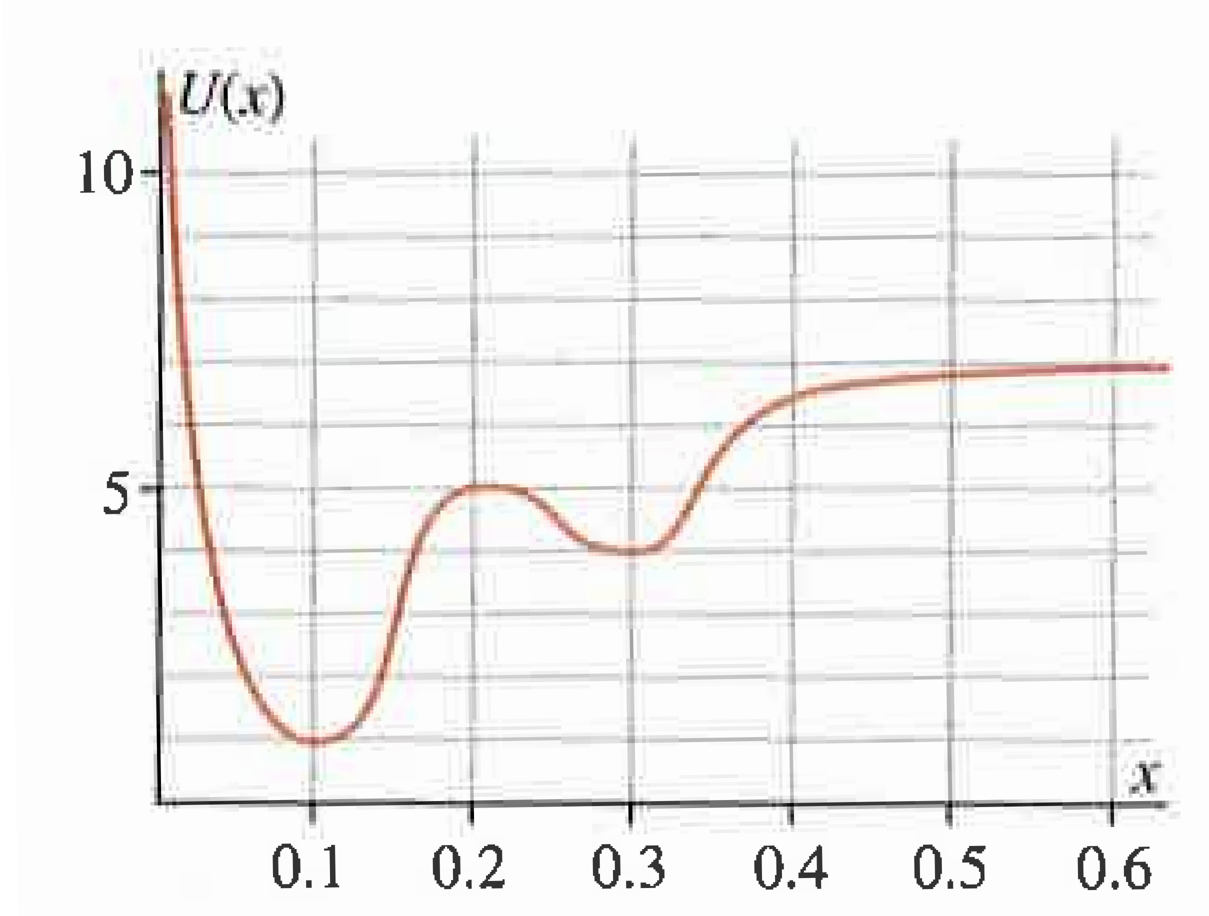
REVIEW QUESTION

This is a finite wave function for a particle in a finite quantum well. What is the particle's quantum number (n)?



Answer: 4

Consider the figure to the right.

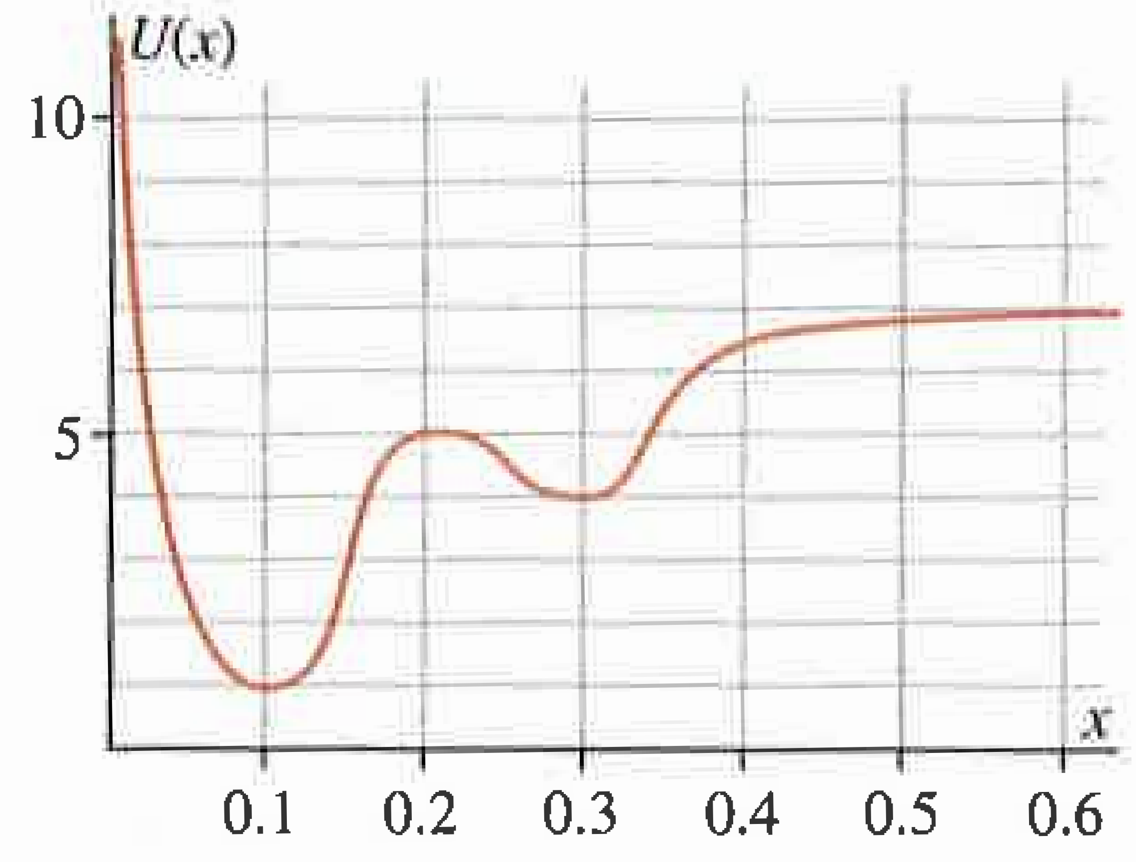


a) How much energy could a classical particle have and still be bound?

Ans: It could have an energy value of 7. Above that it would no longer be bound from the right.

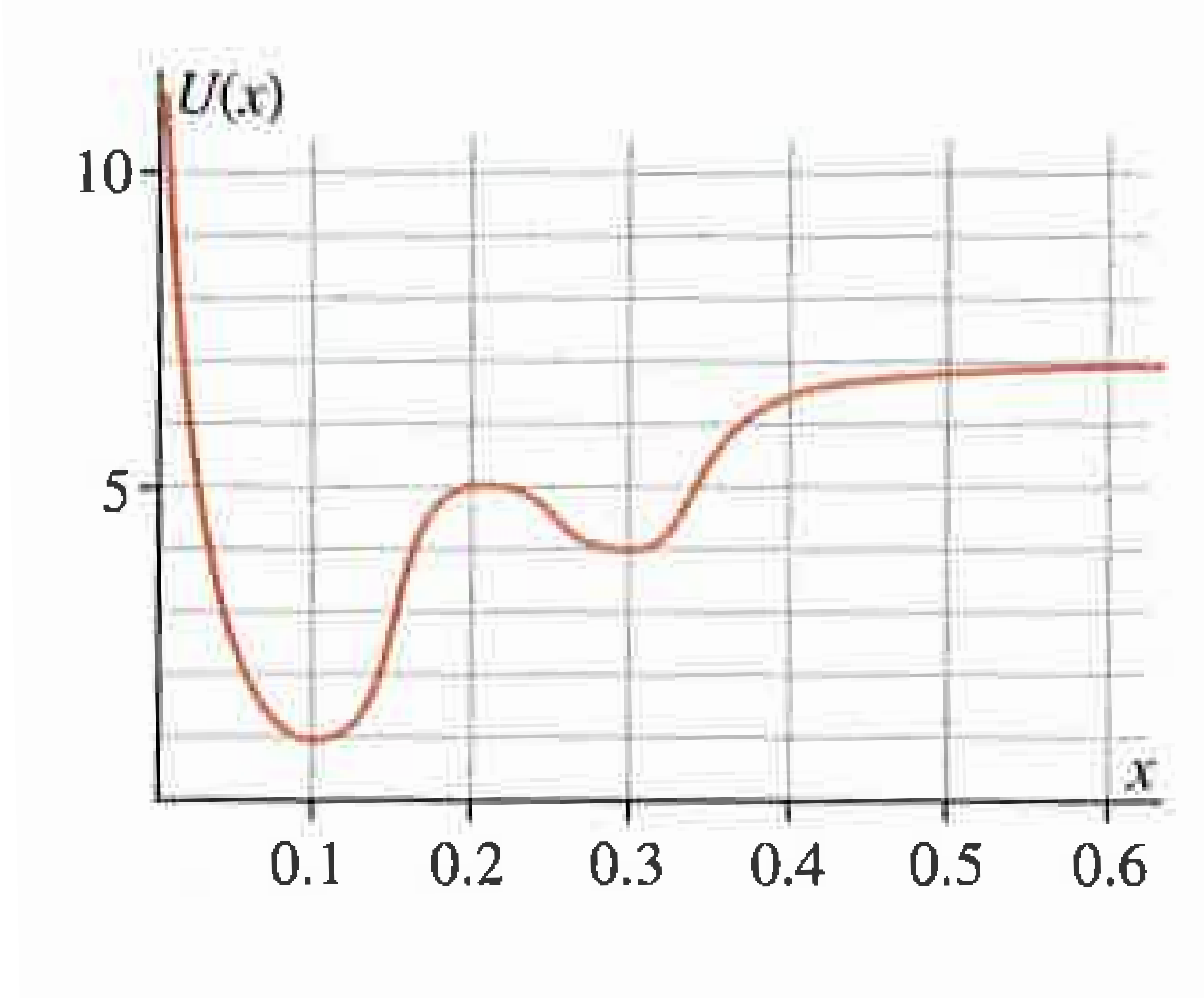
Consider the energy figure to the right.

b) At what value of x would an unbound particle have its maximum kinetic energy?



Ans: It would have maximum kinetic energy at x = 0.1. This is where the potential energy is minimum and hence, the kinetic energy is maximum.

Consider the energy figure to the right.



c) For which range of energies might a classical particle be bound in either of two different regions?

Ans: We are looking for the region where the particle could be bound in the well around x = 0.1 or the well around x = 0.3. The range of energies that correspond to both of those wells is 4 - 5.

Review from Video Lecture:

Expectation Values:

The total probability of finding a particle in an experiment is given by:

$$P = \int |\psi|^2 dx = 1$$

If we want to know the expectation of finding the particle around a given point x, then

$$\bar{x} \equiv \int_{all\ \ space} x|\psi(x)|^2 dx$$

This is the expectation value.

Beware! The expectation value is not an average value of the location of a particle. That suggests a particle has a position. This idea is contrary to the modern view of quantum mechanics.

Review from Video Lecture:

What does this mean schematically?

- $\hat{Q}\Psi(x,t)$ is the act of making the measurement which puts the wave function into some definite state.
- $\Psi^*(x,t)(\hat{Q}\ \Psi(x,t))$ is the probability of that outcome, given the original wave function.
- Integrating gives you the expectation value for that measurement.

What are some operators?

TABLE 5.2 Basic operators

Observable	Momentum	Position	Energy
Operator	$\hat{p} = -i\hbar\frac{\partial}{\partial x}$	$\hat{x} = x$	$\hat{E} = i\hbar\frac{\partial}{\partial t}$

Compute the expectation value of the x-component of the momentum of a particle of mass m in the n = 3 level of a one-dimensional infinite square well of width L.

$$\bar{p} = \int_{-\infty}^{\infty} \Psi^* \hat{p} \Psi dx$$

$$= \int_{-\infty}^{\infty} \sqrt{\frac{2}{L}} \sin\frac{3\pi x}{L} (-i\hbar \frac{\partial}{\partial x}) \sqrt{\frac{2}{L}} \sin\frac{3\pi x}{L} dx$$

$$= -i\hbar \frac{2}{L} \int_0^L \sin\frac{3\pi x}{L} \frac{\partial}{\partial x} \sin\frac{3\pi x}{L} dx$$

$$= i\hbar \frac{2}{L} \int_0^L (\sin\frac{3\pi x}{L})(\cos\frac{3\pi x}{L})(\frac{3\pi}{L}) dx$$

$$\bar{p} = i\hbar\frac{2}{L}\int_0^L (\sin\frac{3\pi x}{L})(\cos\frac{3\pi x}{L})(\frac{3\pi}{L})dx$$

Use U-substitution:

$$u = \frac{3\pi}{L}x \qquad du = \frac{3\pi}{L}dx$$

$$\bar{p} = i\hbar\frac{2}{L}\int_0^L \sin u \cos u du = i\hbar\frac{2}{L}\frac{\sin^2 u}{2}|_0^L$$

$$= i\hbar\frac{2}{L}(0-0)$$

$$\boxed{\bar{p} = 0}$$

What is the kinetic energy of a particle in the second excited state (n = 3)?

$$E = \frac{9\pi^2\hbar^2}{2mL^2}$$

Reconcile that the expectation value of the momentum is zero.

p_x is a vector pointing half the time in the +x direction and half the time in the -x direction. Energy is a scalar, proportional to v^2, hence always positive.

THE END
(FOR TODAY)

http://ramonaemerson.com/see-the-cat-see-the-cradle/