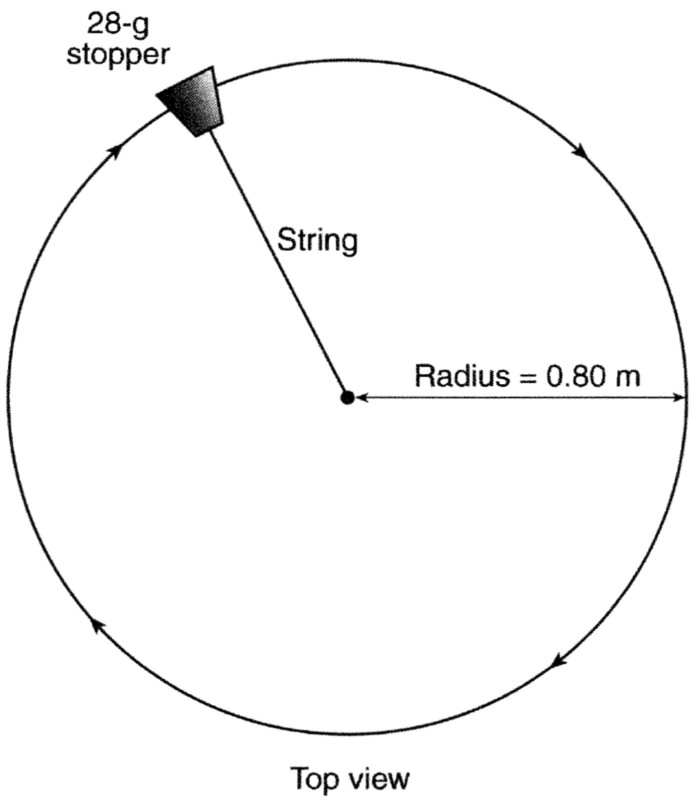
Base your answers to questions **1** and **2** on the information below.

A 28-gram rubber stopper is attached to a string and whirled clockwise in a horizontal circle with a radius of 0.80 meter. The diagram below represents the motion of the rubber stopper. The stopper maintains a constant speed of 2.5 meters per second.



1. Calculate the magnitude of the centripetal acceleration of the stopper. [Show all work, including the equation and substitution with units.]

2. On the diagram above, draw an arrow showing the direction of the centripetal force acting on the stopper when it is at the position shown.

Base your answers to questions **3** through **5** on the information below.

A student and the waxed skis he is wearing have a combined weight of 850 newtons. The skier travels down a snow-covered hill and then glides to the east across a snow-covered, horizontal surface.

3. Determine the magnitude of the normal force exerted by the snow on the skis as the skier glides across the horizontal surface.

_______________________ **N**

4. Calculate the magnitude of the force of friction acting on the skis as the skier glides across the snow-covered, horizontal surface. [Show all work, including the equation and substitution with units.]

5. Calculate the magnitude of the force of friction acting on the skis as the skier glides across the snow-covered, horizontal surface. [Show all work, including the equation and substitution with units.

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6. A cart travels 4.00 meters east and then 4.00 meters north. Determine the magnitude of the cart's resultant displacement.

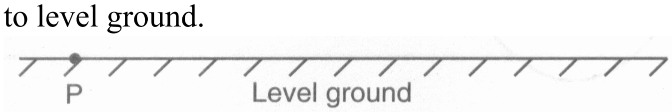
Base your answers to questions **7** through **9** on the information below.

A kicked soccer ball has an initial velocity of 25 meters per second at an angle of 40º above the horizontal, level ground. [Neglect friction.]

7. Calculate the magnitude of the vertical component of the ball's initial velocity [Show all work, including the equation and substitution with units.]

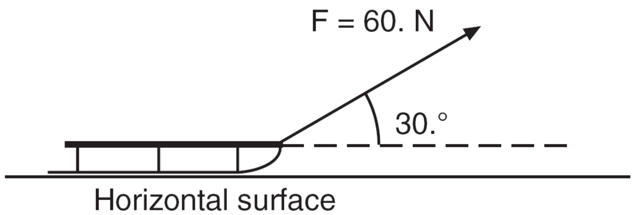
8. Calculate the maximum height the ball reaches above its initial position. [Show all work, including the equation and substitution with units.]

9. On the diagram below, sketch the path of the ball's flight from its initial position at point P until it returns to level ground.



Base your answers to questions **10** and **11** on the information below.

A force of 60. newtons is applied to a rope to pull a sled across a horizontal surface at a constant velocity. The rope is at an angle of 30. degrees above the horizontal.



10. Calculate the magnitude of the component of the 60.-newton force that is parallel to the horizontal surface. [Show all work, including the equation and substitution with units.]

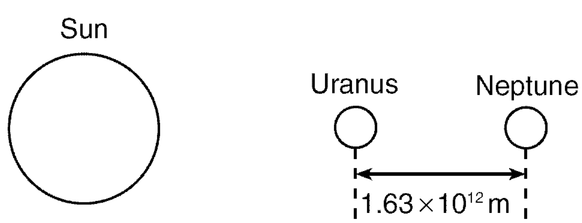
11. Determine the magnitude of the frictional force acting on the sled.

Base your answers to questions **12** through **14** on the passage and data table below.

The net force on a planet is due primarily to the other planets and the Sun. By taking into account all the forces acting on a planet, investigators calculated the orbit of each planet.
A small discrepancy between the calculated orbit and the observed orbit of the planet Uranus was noted. It appeared that the sum of the forces on Uranus did not equal its mass times its acceleration, unless there was another force on the planet that was not included in the calculation. Assuming that this force was exerted by an unobserved planet, two scientists working independently calculated where this unknown planet must be in order to account for the discrepancy. Astronomers pointed their telescopes in the predicted direction and found the planet we now call Neptune.

Data Table

Mass of the Sun	1.99×10^{30} kg
Mass of Uranus	8.73×10^{25} kg
Mass of Neptune	1.03×10^{26} kg
Mean distance of Uranus to the Sun	2.87×10^{12} m
Mean distance of Neptune to the Sun	4.50×10^{12} m



(Not drawn to scale)

12. What fundamental force is the author referring to in this passage as a force between planets?

13. The diagram represents Neptune, Uranus, and the Sun in a straight line. Neptune is 1.63×10^{12} meters from Uranus.

Calculate the magnitude of the interplanetary force of attraction between Uranus and Neptune at this point. [Show all work, including the equation and substitution with units.]

14. The magnitude of the force the Sun exerts on Uranus is 1.41×10^{21} newtons. Explain how it is possible for the Sun to exert a greater force on Uranus than Neptune exerts on Uranus.

Base your answers to questions **15** through **17** on the information and diagram below and on your knowledge of physics.

A jack-in-the-box is a toy in which a figure in an open box is pushed down, compressing a spring. The lid of the box is then closed. When the box is opened, the figure is pushed up by the spring. The spring in the toy is compressed 0.070 meter by using a downward force of 12.0 newtons.

15. Calculate the spring constant of the spring. [Show all work, including the equation and substitution with units.]

16. Calculate the total amount of elastic potential energy stored in the spring when it is compressed. [Show all work, including the equation and substitution with units.]

17. Identify *one* form of energy to which the elastic potential energy of the spring is converted when the figure is pushed up by the spring.

Base your answers to questions **18** through **20** on the information below.

A roller coaster car has a mass of 290. kilograms. Starting from rest, the car acquires 3.13×10^5 joules of kinetic energy as it descends to the bottom of a hill in 5.3 seconds.

18. Calculate the height of the hill. [Neglect friction.] [Show all work, including the equation and substitution with units.]

19. Calculate the speed of the roller coaster car at the bottom of the hill. [Show all work, including the equation and substitution with units.]

20. Calculate the magnitude of the average acceleration of the roller coaster car as it descends to the bottom of the hill. [Show all work, including the equation and substitution with units.]

Base your answers to questions **21** through **24** on the information below and on your knowledge of physics.

A student constructed a series circuit consisting of a 12.0-volt battery, a 10.0-ohm lamp, and a resistor. The circuit does *not* contain a voltmeter or an ammeter. When the circuit is operating, the total current through the circuit is 0.50 ampere.

21. In the space, draw a diagram of the series circuit constructed to operate the lamp, using symbols from the *Reference Tables for Physical Setting/Physics.*

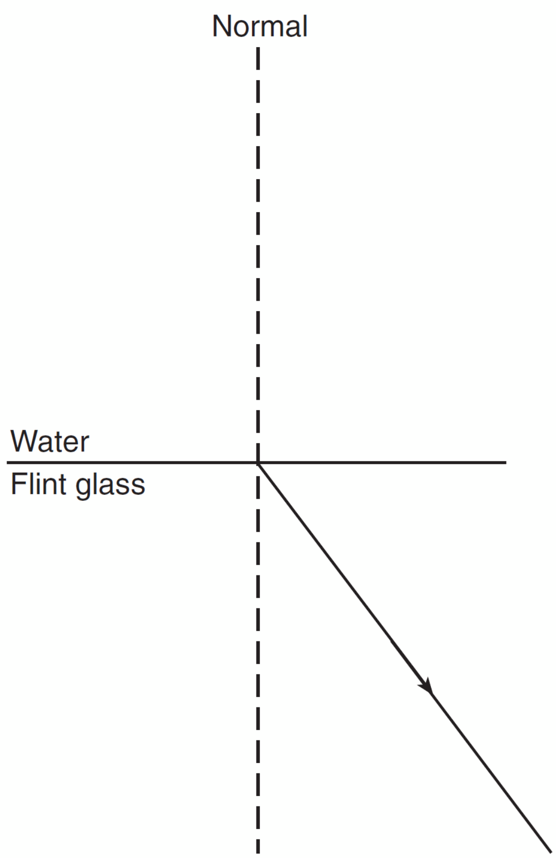
22. Determine the equivalent resistance of the circuit.

23. Determine the resistance of the resistor.

24. Calculate the power consumed by the lamp. [Show all work, including the equation and substitution with the units.]

Base your answers to questions **25** through **28** on the information below.

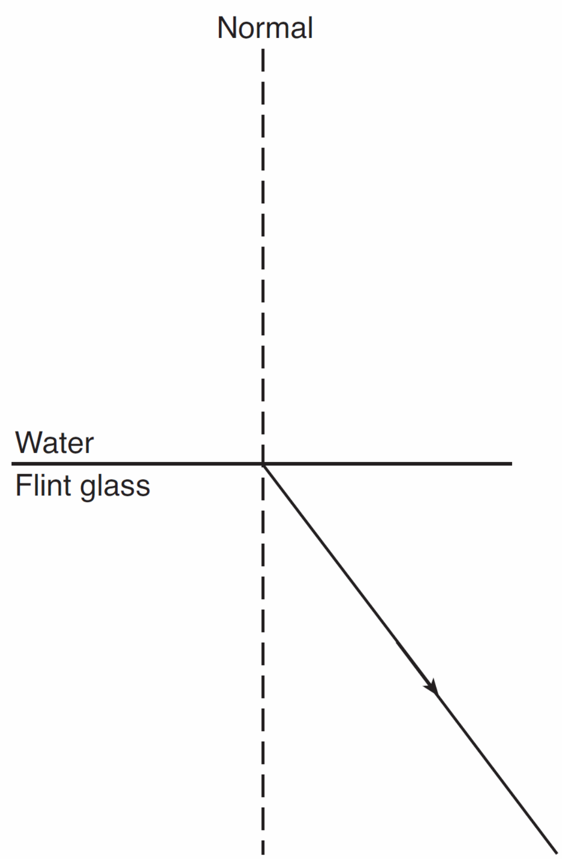
A light ray ($f = 5.09 \times 10^{14}$ Hz) is refracted as it travels from water into flint glass. The path of the light ray in the flint glass is shown in the diagram below.



25. Using a protractor, measure the angle of refraction of the light ray in the flint glass.

26. Calculate the angle of incidence for the light ray in water. [Show all work, including the equation and substitution with units.]

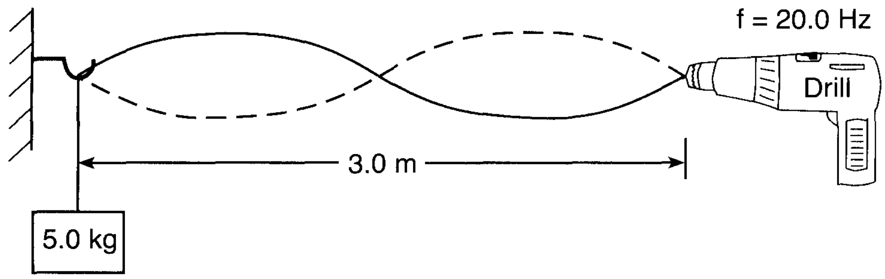
27. Using a protractor and straightedge, on the diagram below, draw the path of the incident light ray in the water.



28. Identify *one* physical event, other than transmission or refraction, that occurs as the light interacts with the water-flint glass boundary.

29. Base your answer to the following question on the information below.

One end of a rope is attached to a variable speed drill and the other end is attached to a 5.0-kilogram mass. The rope is draped over a hook on a wall opposite the drill. When the drill rotates at a frequency of 20.0 Hz, standing waves of the same frequency are set up in the rope. The diagram below shows such a wave pattern.



Calculate the speed of the wave in the rope. [Show all work, including the equation and substitution with units.]

Base your answers to questions **30** through **32** on the information below.

A stationary research ship uses sonar to send a 1.18×10^3-hertz sound wave down through the ocean water. The reflected sound wave from the flat ocean bottom 324 meters below the ship is detected 0.425 second after it was sent from the ship.

30. Calculate the speed of the sound wave in the ocean water. [Show all work, including the equation and substitution with units.]

31. Calculate the wavelength of the sound wave in the ocean water. [Show all work, including the equation and substitution with units.]

32. Determine the period of the sound wave in the ocean water.

Base your answers to questions **33** through **36** on the information below.

Two experiments running simultaneously at the Fermi National Accelerator Laboratory in Batavia, Ill., have observed a new particle called the cascade baryon. It is one of the most massive examples yet of a baryon—a class of particles made of three quarks held together by the strong nuclear force—and the first to contain one quark from each of the three known families, or generations, of these elementary particles.

Protons and neutrons are made of up and down quarks, the two first-generation quarks. Strange and charm quarks constitute the second generation, while the top and bottom varieties make up the third. Physicists had long conjectured that a down quark could combine with a strange and a bottom quark to form the three-generation cascade baryon.

On June 13, the scientists running Dzero, one of two detectors at Fermilab's Tevatron accelerator, announced that they had detected characteristic showers of particles from the decay of cascade baryons. The baryons formed in proton-antiproton collisions and lived no more than a trillionth of a second. A week later, physicists at CDF, the Tevatron's other detector, reported their own sighting of the baryon...

Source: D.C., "Pas de deux for a three-scoop particle," Science News, Vol. 172, July 7, 2007

33. What is the magnitude and sign of the charge, in elementary charges, of a cascade baryon?

34. Which combination of *three* quarks will produce a neutron?

35. The Tevatron derives its name from teraelectronvolt, the maximum energy it can impart to a particle. Determine the energy, in joules, equivalent to 1.00 teraelectronvolt.

36. Calculate the maximum total mass, in kilograms, of particles that could be created in the head-on collision of a proton and an antiproton, each having an energy of 1.60×10^{-7} joule. [Show all work, including the equation and substitution with units.]

Base your answers to questions **37** through **39** on the information below.

A photon with a wavelength of 2.29×10^{-7} meter strikes a mercury atom in the ground state.

37. Calculate the energy, in joules, of this photon. [Show all work, including the equation and substitution with units.]

38. Determine the energy, in electronvolts, of this photon.

________________________ **eV**

39. Based on your answer to the question above, state if this photon can be absorbed by the mercury atom. Explain your answer.