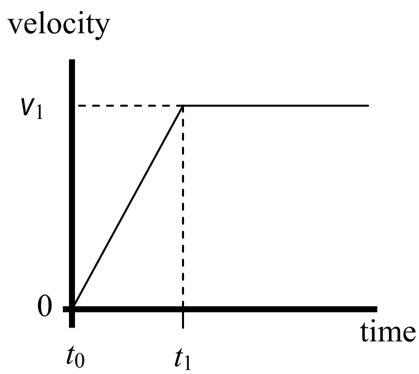
Questions from April 2005 Physics 111.6 Final Exam

A1. The figure shows a graph of speed versus time for an object moving along a straight line. Which one of the following statements is ***not*** correct?



(A) The object has a zero speed only at time t_0.
(B) The average speed between times t_0 and t_1 is $\bar{v} = \dfrac{v_1}{t_1 - t_0}$.
(C) The object has a constant speed after time t_1.
(D) The object has a zero acceleration after time t_1.
(E) The object has constant acceleration between times t_0 and t_1.

A2. A skydiver is suspended from a parachute, at a height of 2000 m above the surface of the Earth. She has a constant velocity downwards. Which one of the following statements concerning the forces acting on the skydiver is ***not*** correct?

(A) The magnitude of the gravitational force depends on the value of the acceleration due to gravity.
(B) The gravitational force is opposed by a friction force due to air resistance.
(C) The gravitational force and the friction force due to air resistance act in opposite directions.
(D) The magnitude of the friction force due to air resistance is less than the magnitude of the gravitational force.
(E) The friction force due to air resistance is a non-conservative force.

A3. Two identical masses are connected to a massless string which is hung over two frictionless ideal pulleys. If everything in the system is at rest and remains at rest, the magnitude of the tension in the cord is

(A) less than mg.
(B) mg.
(C) more than mg but less than $2mg$.
(D) $2\,mg$.
(E) more than $2\,mg$.

A4. Which one of the following is the correct expression for the speed v of a satellite in a circular orbit at an altitude of h above the surface of the Earth? You may assume that the satellite is in uniform circular motion and that the Earth is a perfect sphere with radius r_E and a mass M_E.

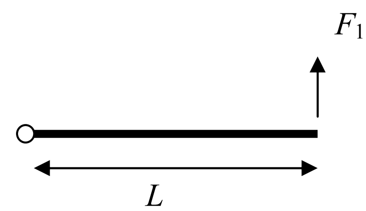
(A) $v = \sqrt{\dfrac{GM_E}{h}}$ (B) $v = \sqrt{\dfrac{GM_E}{h^3}}$ (C) $v = \sqrt{\dfrac{GM_E}{h + r_E}}$

(D) $v = \sqrt{\dfrac{GM_E}{(h + r_E)^2}}$ (E) $v = \sqrt{\dfrac{h + r_E}{GM_E}}$

A5. A person lifts a heavy object to a height h in a time t. The work done on the object by the person is W. If this person had taken twice as long to lift the object, the work done by the person would have been

(A) $W/4$. (B) $W/2$. (C) W. (D) $2W$. (E) $4W$.

A6. A torque τ is exerted on a bolt by exerting a force F_1 acting in a perpendicular direction on a wrench of length L. The force is now doubled and the wrench is replaced by one that is twice as long. The force is applied in a perpendicular direction at the end of the wrench furthest from the bolt. The new torque exerted on the bolt is



(A) τ/4 (B) τ/2 (C) τ (D) 2τ (E) 4τ

A7. A mass connected to an ideal spring is displaced from the equilibrium position by a distance x and released. Which one of the following statements concerning elastic potential energy is ***not*** correct?

(A) The elastic potential energy has the SI unit of Joule.
(B) The elastic potential energy is zero at certain times.
(C) The elastic potential energy is a maximum when the displacement x is zero.
(D) The elastic potential energy is converted into kinetic energy as the mass moves toward the equilibrium position.
(E) The elastic potential energy is a positive quantity.

A8. A longitudinal wave on a Slinky of length X metres has a period of T seconds and travels the length of the Slinky in a time of t seconds. Which one of the following expressions is correct for the wavelength of the wave?

(A) $\lambda = \frac{X}{Tt}$ (B) $\lambda = \frac{Xt}{T}$ (C) $\lambda = \frac{XT}{t}$

(D) $\lambda = \frac{Tt}{X}$ (E) $\lambda = XTt$

A9. A wave is described by the equation

$$y = 8\sin\left[2\pi\left(\frac{t}{2} - \frac{x}{20}\right)\right]$$

where all distances are measured in centimetres and the time is measured in seconds. Which one of the following statements is correct?

(A) The amplitude is 4 cm.
(B) The wavelength is 10/π cm.
(C) The period is 2 s.
(D) The frequency is 2 Hz.
(E) The wave is travelling to the left (in the negative x direction).

A10. An observer is moving toward a sound source at a speed of 2 m/s. The sound source is also moving toward the observer at a speed of 2 m/s. If the source is emitting a frequency f_s, which of the following expressions is correct for the frequency f_o which the observer hears? The speed of sound is v m/s.

(A) $f_o = f_s\left(\frac{v-2}{v+2}\right)$ (B) $f_o = f_s$ (C) $f_o = f_s\left(\frac{v+2}{v}\right)$

(D) $f_o = f_s\left(\frac{v}{v-2}\right)$ (E) $f_o = f_s\left(\frac{v+2}{v-2}\right)$

A11. A tension T is applied to a guitar string of length L that is fixed at its ends. The fundamental resonant frequency is f. The string is now cut in half. One of the pieces (of length $L/2$) is fixed at both ends and the same tension T is applied. The fundamental frequency of the shortened string is

(A) $\frac{f}{4}$. (B) $\frac{f}{2}$. (C) f. (D) $2f$. (E) $4f$.

A12. A silver coin initially has a net charge of Q. The coin is brought into contact with an identical (but initially uncharged) coin. The two coins are then separated and the second coin is brought into contact with a third identical (initially uncharged) coin. The resulting charge on the third coin is

(A) $\frac{Q}{4}$. (B) $\frac{Q}{3}$. (C) $\frac{Q}{2}$. (D) $\frac{2Q}{3}$. (E) $\frac{3Q}{2}$.

A13. Four point charges are placed at the corners of a square. Each charge has an identical value of $+Q$. The length of the diagonal of the square is $2a$. Which one of the following correctly expresses the electric potential at the centre of the square?

(A) $\frac{kQ}{a}$ (B) $\frac{2kQ}{a}$ (C) $\frac{4kQ}{a}$ (D) $\frac{kQ}{4a}$ (E) 0

A14. Two resistors, R_1 and R_2, are connected in parallel across the terminals of a battery of emf V. Which one of the following expressions is correct for the current, I, drawn from the battery?

(A) $I = V\frac{R_1R_2}{(R_1+R_2)}$ (B) $I = V\frac{R_1}{(R_1+R_2)}$ (C) $I = V\frac{R_2}{(R_1+R_2)}$

(D) $I = V\frac{(R_1+R_2)}{R_1R_2}$ (E) $I = V\frac{R_2}{R_1}$

A15. As defined in the law of reflection, the angle of incidence is

(A) the angle between the incident ray and the reflected ray.
(B) the angle between the incident ray and the normal drawn at the point where this ray meets the reflecting object.
(C) the angle between the incident ray and the surface of the reflecting object.
(D) the angle between the reflected ray and the surface of the reflecting object.
(E) equal to half the angle between the reflected ray and the surface of the reflecting object.

A16. A girl has a near point of 1.5 m. Which one of the following statements is correct?

(A) She has normal vision.
(B) She is myopic (nearsighted) and requires diverging lenses to correct her vision.
(C) She is myopic (nearsighted) and requires converging lenses to correct her vision.
(D) She is hyperopic (farsighted) and requires diverging lenses to correct her vision.
(E) She is hyperopic (farsighted) and requires converging lenses to correct her vision.

A17. Light of a particular wavelength is incident on a metal surface, and electrons are emitted from the surface as a result. To produce more electrons per unit time but with less kinetic energy per electron, the experimenter should do which of the following?

(A) Increase the intensity and decrease the wavelength of the light.
(B) Increase the intensity and the wavelength of the light.
(C) Decrease the intensity and the wavelength of the light.
(D) Decrease the intensity and increase the wavelength of the light.
(E) It is not possible to produce the desired result.

A18. Correctly complete the following sentence: The results of the Rutherford scattering experiment provide evidence that

(A) electrons in an atom can only have certain energies.
(B) electromagnetic radiation can exhibit particle characteristics when interacting with electrons in a material.
(C) light of sufficiently high frequency can cause electrons to be emitted from a metal surface.
(D) the energy of a photon is determined by its frequency.
(E) the positive charge of an atom is contained in a small region (the nucleus).

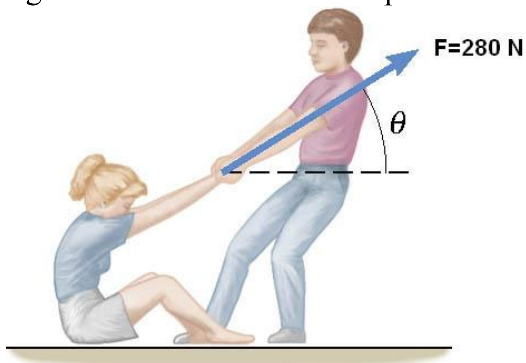
A19. An electron in an atom moves in an orbit of radius r. When the principal quantum number of the electron changes by a factor of 3 ($n \to 3n$), the new orbit radius is

(A) $\frac{r}{9}$. (B) $\frac{r}{3}$. (C) r. (D) $3r$. (E) $9r$.

A20. $^{232}_{90}Th$ decays via α-particle emission producing a daughter nucleus that itself decays via β^- emission. Identify the final nucleus that results from these two decays.

(A) $^{226}_{88}Ra$ (B) $^{228}_{89}Ac$ (C) $^{218}_{85}At$ (D) $^{210}_{82}Pb$ (E) $^{239}_{94}Pu$

B1. Your friend has slipped. To pull her up, you pull with a force of magnitude 280 N as shown in the diagram. If the horizontal component of the force is 145 N, calculate the angle θ.



B2. You are in the basket of a hot air balloon that is rising straight up. You hold an object over the side of the basket and, when the object is 10.2 m above the ground, you release it. If the object takes 2.70 s to fall to the ground, calculate the speed of the object relative to the ground (due to the upward motion of the balloon) at the instant that it was released.

B3. A sled is sliding along a horizontal icy surface, decelerating at 1.04 m/s^2. Calculate the coefficient of kinetic friction between the sled and the ice.

B4. A disk is rotating about an axis that passes through its centre and is perpendicular to the disk. The initial angular velocity is –0.278 rad/s and the angular acceleration is constant at +0.148 rad/s^2. Calculate the angular displacement of the disk after 5.55 seconds.

B5. When a force of magnitude 89.0 N is applied to an ideal spring it is compressed by 0.0192 m. Calculate the magnitude of the force required to compress the spring by 0.0514 m.

B6. At its closest approach to Earth, Mars is 5.60×10^{10} m away. Calculate the time required for a radio transmission to travel from Mars to Earth.

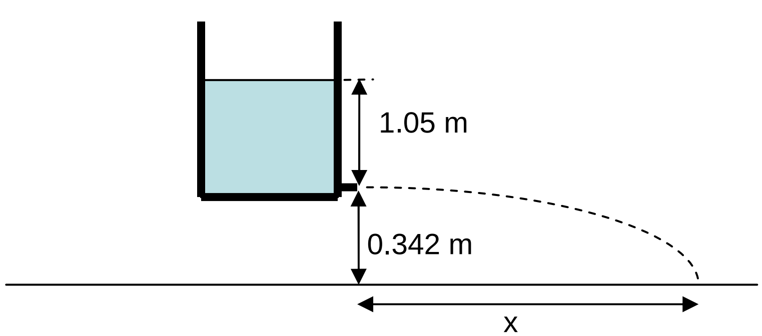
B7. The filament of a light bulb has a resistance of 580 Ω. A voltage of 12.0 V is applied across the filament. Calculate the number of electrons that pass through the filament in 60.0 seconds.

B8. Calculate the critical angle for light in a diamond that is immersed in water. The refractive index of diamond is 2.42 and the refractive index of water is 1.33.

B9. Consider a Young's double-slit interference pattern. It is observed that for light with a wavelength of 455 nm, the angle between the zeroth order maximum and the second order maximum is 6.30×10^{-3} radians. Calculate the slit separation.

B10. The half-life of a radioactive substance is 4.50 days. If 3.00 g of radioactive material remain after 2.00 days of decay, calculate the mass of radioactive material initially in the sample.

C1. An open topped barrel contains wine. The surface of the wine in the barrel is 1.05 m above the level of the exit pipe. The open, circular cross section, exit pipe of diameter 2.50 cm is 0.342 m above the ground. You may assume that the change in the level of the wine in the barrel is negligible and that the wine exits from the pipe horizontally.



(a) Calculate the exit speed of the wine from the pipe.

If you did not obtain an answer for the exit speed of the wine in part (a), use a value of 4.25 m/s as necessary in (b), (c), and (d).

(b) Calculate the volume flow rate of the wine from the pipe.

(c) Calculate the elapsed time from the wine leaving the exit pipe to the wine hitting the floor.

(d) Calculate the horizontal distance x from the end of the exit pipe to the point where the wine hits the floor. Remember to express your answer to 3 significant figures.

C2. Spacecraft A, of mass m_A and travelling with an initial velocity of v_A, docks with a stationary space station of mass m_S.

(a) If no external forces are present, show that the final velocity v_f of the combined spacecraft and space station after the spacecraft has docked is given by

$v_f = \left(\frac{m_A}{m_A + m_S}\right) v_A$. Clearly state the physical principle used in deriving the equation.

The spacecraft has a mass of 9.05×10^4 kg, the space station has a mass of 8.05×10^5 kg, and the spacecraft had an initial velocity of 0.100 m/s.

(b) Calculate the initial kinetic energy of the spacecraft and the final kinetic energy of the combined spacecraft and space station. Is the collision elastic or inelastic? Justify your reasoning.

(c) A thruster rocket is now fired for 12.0 seconds to bring the combined spacecraft and space station to a halt. Calculate the magnitude of the average force exerted by the thruster rocket.

C3. In a collision with a free electron, which is initially at rest, a photon of energy 2.0000×10^3 eV is deflected by 90.000°.

Perform all calculations to 5 significant figures. Use the following values for the constants that may be required in your calculations: $h = 6.626\,068 \times 10^{-34}$ J·s $= 4.135\,667 \times 10^{-15}$ eV·s; $m_e = 9.109\,390 \times 10^{-31}$ kg; $e = 1.602\,176 \times 10^{-19}$ C; $c = 2.997\,924 \times 10^8$ m/s

(a) Calculate the wavelength of the incident photon.

(b) Calculate the wavelength of the scattered photon.

(c) Calculate the speed of the scattered electron.

(d) This experiment was performed in a laboratory in Saskatoon where the magnitude of the magnetic field is 5.8387×10^{-5} T. Calculate the magnitude of the maximum possible magnetic force exerted on the electron.