Questions from April 2002 Physics 111.6 Final Exam

A1. A rock is thrown straight up from the Earth's surface. Which one of the following statements is true concerning the net force acting on the rock at the top of its path?
- (A) It is equal to the weight of the rock.
- (B) It is instantaneously equal to zero.
- (C) Its direction changes from up to down.
- (D) It is greater than the weight of the rock.
- (E) It is less than the weight of the rock, but greater than zero.

A2. The total mechanical energy of a system
- (A) is always equally divided between kinetic energy and potential energy.
- (B) is either all kinetic energy or all potential energy, at any particular instant.
- (C) can never be negative.
- (D) is constant if only conservative forces are acting on the system.
- (E) decreases uniformly with time if only conservative forces are acting on the system.

A3. Which one of the following numbers is **not** expressed to three significant figures?

(A) 245 (B) 0.00136 (C) 45.0 (D) 3.69×10^4 (E) 0.097

A4. The speed of a satellite in a stable circular orbit around the Earth is independent of the
- (A) universal gravitational constant.
- (B) mass of the Earth.
- (C) radius of the orbit.
- (D) height of the satellite above the Earth's surface.
- (E) mass of the satellite.

A5. A box of mass m is made to move across a horizontal surface by applying a horizontal force of magnitude F. The coefficient of kinetic friction between the box and the surface is μ_k. The work done by the normal force as the box goes through a horizontal displacement of magnitude s is

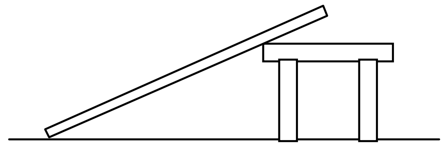
(A) 0 (B) mgs (C) $\mu_k mgs$ (D) Fs (E) $\mu_k Fs$

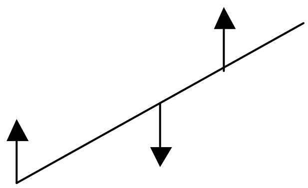
A6. A building with two floors is located on the Earth's equator. Which of the following statements is correct concerning the tangential speeds of the floors due to the Earth's rotation?
- (A) The top floor has a greater tangential speed.
- (B) The bottom floor has a greater tangential speed.
- (C) Both floors have the same non-zero tangential speed.
- (D) The tangential speed of both floors is zero.
- (E) Nothing can be said about the tangential speeds without knowing the height of the building.

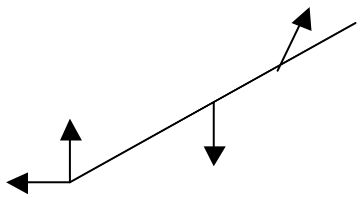
A7. The minus sign in Hooke's Law indicates that
(A) the restoring force is always negative.
(B) the displacement is always negative.
(C) the restoring force has the same sign as the displacement.
(D) the direction of the restoring force is opposite to the direction of the displacement.
(E) the constant *k* is negative and has to be made positive.

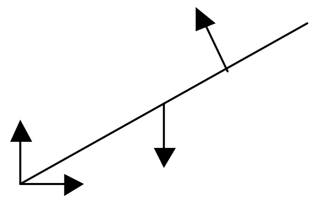
A8. In which one of the following situations does the tip of a rotating fan blade have a tangential acceleration with a magnitude that is constant and non-zero?
(A) The fan has a constant angular velocity.
(B) The fan blade has a constant magnitude centripetal acceleration.
(C) The fan has a constant and non-zero angular acceleration.
(D) The fan has zero angular acceleration.
(E) The fan blade has an increasing angular acceleration.

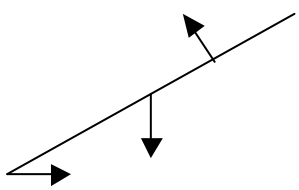
A9. A uniform plank is leaning against a bench as shown. The floor is rough and the plank is stationary. Which one of the following is a correct free body diagram of the forces on the plank?

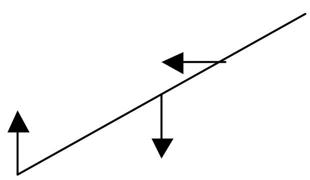


(A) 

(B) 

(C) 

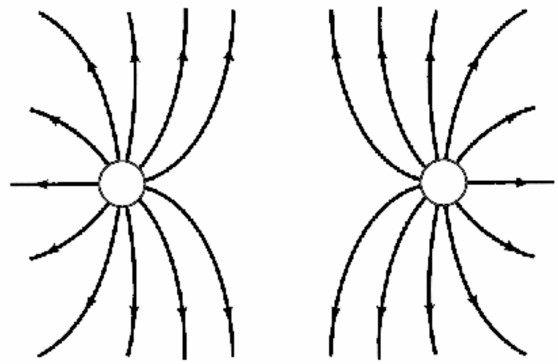
(D) 

(E) 

A10. Consider the standing wave on a guitar string and the sound wave it produces. Which of the following statements concerning these two waves is correct?
(A) They have the same wavelength.
(B) They have the same frequency.
(C) They have the same velocity.
(D) They have the same amplitude.
(E) They have the same intensity.

A11. What configuration of electrical charges could produce the pattern of electric field lines shown in the diagram?

(A) a point charge
(B) an electric dipole
(C) a pair of positive point charges
(D) a pair of negative point charges
(E) a parallel-plate capacitor



A12. The instruction manual for an electric lawnmower states that the extension cord must have a minimum wire diameter of 1 mm. Which of the following is the best explanation for this statement?

(A) If the wire is too thin, the current drawn from the socket will be too high and the extension cord will overheat.
(B) If the wire is too thin, the extension cord will break due to normal wear and tear.
(C) If the wire is too thin, the current drawn from the socket will be too low for the motor to function properly.
(D) If the wire is too thin, one of the household fuses will blow.
(E) If the wire is too thin, the internal resistance of the domestic electricity supply will cause the terminal voltage to drop.

A13. A proton, initially moving vertically upward, enters a region in which there is a magnetic field directed north. The initial direction of the magnetic force on the proton is

(A) up. (B) north. (C) east. (D) west. (E) down.

A14. Which one of the following is true concerning resistivity?

(A) Resistivity is measured in ohms.
(B) Resistivity and resistance are two terms referring to the same physical quantity.
(C) Resistivity is an inherent property of materials.
(D) Resistivity depends on the dimensions of the material.
(E) The resisitivity of conductors is greater than the resisitivity of insulators.

A15. A ray of light in air strikes a water surface at an angle of incidence of 65.0°. The critical angle for a water-air interface is 48.8°. Which of the following statements is correct?

(A) All of the incident light reflects from the water surface.
(B) Some of the light reflects and some refracts into the water. The angle of refraction is less than 65.0°.
(C) Some of the light reflects and some refracts into the water. The angle of refraction is greater than 65.0°.
(D) Some of the light reflects and some refracts into the water. The angle of refraction is 65.0°.
(E) All of the light refracts into the water.

A16. The radioactive isotope ${}^{22}_{11}\text{Na}$ decays into ${}^{22}_{10}\text{Ne}$. This is an example of

(A) α decay (B) β^+ decay (C) β^- decay (D) γ decay (E) neutron decay

A17. An object is placed at a distance d_o from a converging lens of focal length f such that $f < d_o < 2f$. The resulting image is

(A) upright, virtual, enlarged. (B) upright, virtual, reduced.
(C) inverted, real, reduced. (D) inverted, real, enlarged.
(E) upright, real, enlarged.

A18. Which one of the following statements concerning the cutoff wavelength typically exhibited in X-ray spectra is correct?

(A) The cutoff wavelength depends on the target material.
(B) The cutoff wavelength depends on the potential difference across the X-ray tube.
(C) The cutoff wavelength is independent of the energy of the incident electrons.
(D) The cutoff wavelength occurs because of the mutual shielding effects of the K-shell electrons.
(E) The cutoff wavelength occurs because an incident electron cannot give up all of its energy.

A19. You are asked to create a beam of light consisting of parallel rays. Which of the following arrangements should you employ?

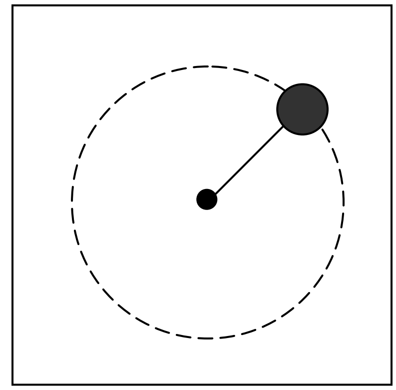
(A) Place a light bulb at a distance equal to half the focal length from a converging lens.
(B) Place a light bulb at the focal point of a diverging lens.
(C) Place a light bulb at the focal point of a converging lens.
(D) Place a light bulb at a distance equal to twice the focal length from a diverging lens.
(E) Place a light bulb at a distance equal to twice the focal length from a converging lens.

A20. Identify X in the following reaction: ${}^{235}_{92}\text{U} + \gamma \rightarrow {}^{142}_{56}\text{Ba} + {}^{90}_{36}\text{Kr} + X$

(A) one alpha particle
(B) two alpha particles
(C) three protons
(D) three neutrons
(E) six neutrons

B1. A ball is thrown with an initial velocity of 20.0 m/s at an angle of 35.0° above the horizontal. Calculate the time required for the ball to reach maximum height.

B2. An object of mass 0.250 kg, on a horizontal, frictionless surface, is attached to a post by a horizontal cable. The object is undergoing uniform circular motion of radius 0.250 m with a period of 2.00 s (experiment M14). Calculate the tension in the cable.



Top View

B3. Object 1 of mass 0.400 kg, with an initial velocity of +5.02 m/s, collides head-on with stationary object 2 of mass 0.800 kg. As a result of the collision, object 2 moves with a velocity of +3.40 m/s. Calculate the **velocity** of object 1 after the collision.

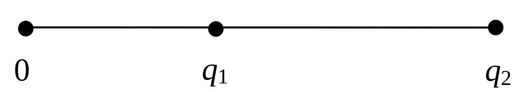
B4. Assume that the Earth is a uniform sphere of radius 6.38×10^{6} m and mass 5.98×10^{24} kg. Calculate the kinetic energy of the Earth due to its rotation about its axis.

B5. A car, while sounding its horn, is speeding away from a stationary police constable (who is also a concert violinist). The constable notes that the horn sound that he hears has a frequency of exactly 440 Hz (middle A). His radar gun indicates that the speed of the car is 18.1 m/s. Calculate the frequency of the car's horn. The speed of sound in air is 343 m/s.

B6. Two loads, with resistances of 10.0 Ω and 12.0 Ω, are connected in parallel across an ideal battery of emf 15.0 V. Calculate the total current drawn from the battery.

B7. A certain FM radio station broadcasts at a frequency of 93.3 MHz. Calculate the wavelength of the radio wave produced by the transmitter.

B8. Two charges, q_1 and q_2, are placed on the x-axis. $q_1 = +8.00 \times 10^{-6}$ C is located at $x_1 = +0.0300$ m and $q_2 = -19.0 \times 10^{-6}$ C is located at $x_2 = +0.0850$ m. Calculate the **magnitude** of the net electric field at the origin.



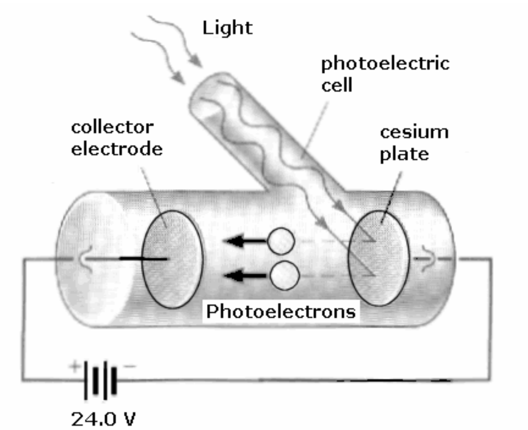
B9. An isotope of iodine has a half-life of 8.04 days. Calculate the percentage of radioactive iodine nuclei remaining in a sample after 30.0 days.

B10. A farsighted person has a nearpoint of 1.15 m. Calculate the corrected nearpoint when the person wears contact lenses of refractive power 6.44 diopters.

C1. Four people, each of mass 80.0 kg, are stranded on an island. They decide to build a raft to return to civilization. The raft will be made of logs of density 725 kg/m^3, radius 0.0800 m, and length 3.00 m. The raft must be designed to keep the four people dry, i.e. the raft must float so that the top surface of the logs must be at or above the surface of the water. The density of sea water is 1.03×10^3 kg/m^3.

Calculate the minimum number of whole logs required for the raft.

C2. In a photoelectric experiment, light illuminates a cesium plate. Photoelectrons are produced with a maximum kinetic energy of 10.5 eV. The photoelectric cell is connected to a circuit as shown in the diagram. The distance between the electrodes is 10.0 cm and the electric field in the region between the electrodes is uniform. The battery has an emf of 24.0 V.



(a) Calculate the magnitude of the acceleration of the photoelectrons after they are ejected from the cesium plate.

(b) Calculate the maximum kinetic energy (in eV) of the photoelectrons when they reach the positive electrode.

(c) Suppose the light intensity is such that 17,000 electrons are ejected from the cesium plate every second. Calculate the resultant photocurrent.

C3. Light from a hydrogen source strikes a diffraction grating. The diffraction grating has 600 lines/mm. One of the spectral lines is observed to occur at an angle of 15.1° in first order.

(a) Calculate the wavelength of the spectral line described above.

(b) Using the Bohr model, calculate the quantum number of the initial state that gives rise to the spectral line described above. (Recall that the final state corresponds to $n = 2$ for the visible lines of hydrogen. If you did not obtain an answer for (a) use a wavelength of 410 nm.)

(c) The spectral line described above illuminates a metal surface that has a work function of 2.30 eV. Calculate the maximum speed of the electrons ejected from this surface. (If you did not obtain an answer for (a), use a wavelength of 410 nm.)