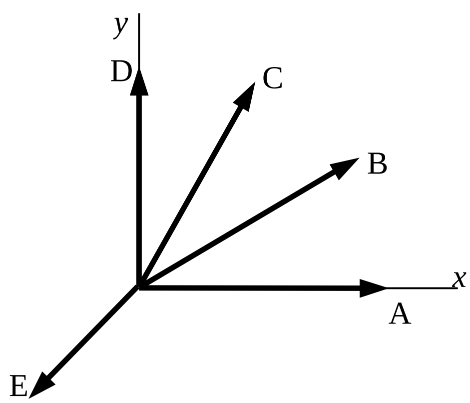
Questions from April 1999 Physics 111.6 Final Examination

A1. The driver of an automobile is initially travelling at constant velocity on a straight road. Due to the sudden appearance of a pedestrian, the driver brakes and decelerates with a magnitude of 15.0 m/s^2 in order to avoid a collision. Which one of the following statements concerning the automobile's motion is correct?
(A) The direction of the acceleration is the same as the direction of the displacement.
(B) The direction of the acceleration is the same as the direction of the velocity.
(C) The automobile travels a distance of 15.0 m *only* during the first second of the deceleration.
(D) The automobile travels a distance of 15.0 m during each second of the deceleration.
(E) The speed of the automobile decreases by 15.0 m/s during each second of the deceleration.

A2. An object of mass m is thrown at an angle of θ_o above the horizontal with an initial speed of v_o. Ignoring any frictional effects, the acceleration of the object while in the air is
(A) dependent on the launch angle θ_o, but not on the initial speed v_o.
(B) dependent on the initial speed v_o, but not on the launch angle θ_o.
(C) dependent on both the launch angle θ_o and the initial speed v_o.
(D) dependent on the object's mass m.
(E) constant.

A3. An object is acted upon by two and only two forces. Force 1 acts in the $+x$ direction and force 2 acts in the $+y$ direction. The magnitude of force 1 is greater than the magnitude of force 2. Which of the vectors shown in the diagram best represents the direction of the acceleration of the object?



A4. During a space-walk, an astronaut of mass m_1 pushes on a satellite of mass m_2 with a force $\vec{F}$. The force exerted by the satellite on the astronaut is

(A) 0 (B) $-\frac{m_1}{m_2}\vec{F}$ (C) $-\frac{m_2}{m_1}\vec{F}$ (D) $-\vec{F}$ (E) $-\frac{m_1}{m_1+m_2}\vec{F}$

A5. A skydiver jumps from an airplane and undergoes free-fall toward the ground. The diver's parachute then opens, and the diver then falls toward the ground with constant speed. The net work done on the skydiver is
(A) positive before the parachute opens and negative after the parachute has opened.
(B) positive before the parachute opens and zero after the parachute has opened.
(C) zero before the parachute opens and zero after the parachute has opened.
(D) negative before the parachute opens and positive after the parachute has opened.
(E) negative before the parachute opens and zero after the parachute has opened.

A6. Consider the following four objects, each of mass M and radius R: a hoop, a flat disk, a solid sphere, and a hollow sphere. An axis of rotation passes through the centre of each object, and is perpendicular to the plane of the hoop and the plane of the flat disk. Which object requires the largest torque to give it the same angular acceleration as the rest of the objects?
(A) the hoop (B) the flat disk (C) the solid sphere (D) the hollow sphere
(E) all the objects require the same torque.

A7. A speaker is emitting sound uniformly in all directions. At a distance of 1 m from the source of sound, energy enters your ears at a rate P. At a distance of 2 m from the source the rate at which sound energy enters your ears is
(A) P (B) $2P$ (C) $4P$ (D) $\frac{1}{4}P$ (E) ½ P

A8. Which one of the following statements concerning a completely enclosed fluid is correct?
(A) Any change in the applied pressure of the fluid produces a change in pressure that depends on direction.
(B) The pressure at all points within the fluid is independent of any pressure applied to it.
(C) Any change in applied pressure produces an equal change in pressure at all points within the fluid.
(D) An increase in pressure in one part of the fluid results in an equal decrease in pressure in another part.
(E) The pressure in the fluid is the same at all points within the fluid.

A9. A steel cable is used to lower a research submarine from the air into the water to a depth of 100 m. Which one of the following statements is correct?
(A) The tension in the cable remains constant as the submarine is lowered from the air into the water.
(B) The tension in the cable increases as the submarine contacts the water and continues to increase until the submarine is fully submerged, after which the tension is constant.
(C) The tension in the cable decreases as the submarine contacts the water and continues to decrease until the submarine is fully submerged, after which the tension is constant.
(D) The tension in the cable increases as the submarine contacts the water and continues to increase throughout the lowering of the submarine to its final depth.
(E) The tension in the cable decreases as the submarine contacts the water and continues to decrease throughout the lowering of the submarine to its final depth.

A10. Two guitar strings are the same length and under the same tension but the mass of string 1 is four times that of string 2 ($m_1 = 4\,m_2$). If the fundamental frequency of string 2 is f_2, the fundamental frequency of string 1 is
(A) $4\,f_2$ (B) $2\,f_2$ (C) f_2 (D) $\frac{1}{2}\,f_2$ (E) $\frac{1}{4}\,f_2$

A11. Each of three objects has a net charge. Objects **A** and **B** attract one another. Objects **B** and **C** also attract one another, but objects **A** and **C** repel one another. Which one of the following table entries is a possible combination of the signs of the net charges on these three objects?

	A	B	C
(A)	+	+	–
(B)	–	+	+
(C)	+	–	–
(D)	–	+	–
(E)	–	–	+

A12. Two identical resistors of resistance *R* are connected in parallel. The equivalent resistance of this parallel combination is

(A) *R* (B) 2 *R* (C) 4 *R* (D) ½ *R* (E) 2/*R*

A13. An electron travels through a region of space with no acceleration. **E** is the electric field in the region and **B** is the magnetic field in the region. Which one of the following statements is the **best** conclusion? (Ignore gravitational effects.)

(A) Both **E** and **B** *must* be zero in that region.
(B) **E** must be zero, but **B** might be non-zero in that region.
(C) **E** and **B** might both be non-zero, but they must be mutually perpendicular.
(D) **B** must be zero, but **E** might be non-zero in that region.
(E) **E** and **B** might both be non-zero, but they must point in opposite directions.

A14. Which one of the following expressions correctly describes the critical angle for quartz (n = 1.5) immersed in oil (n = 1.1)?

(A) $\theta_c = \frac{1.5}{1.1}$ (B) $\theta_c = \frac{1.1}{1.5}$ (C) $\theta_c = \sin^{-1}\left(\frac{1.5}{1.1}\right)$
(D) $\theta_c = \sin^{-1}\left(\frac{1.1}{1.5}\right)$ (E) $\theta_c = 0$

A15. An interference pattern is obtained in a double-slit experiment using light of wavelength 600 nm. Which one of the following phenomena would be observed if the distance between the slits were increased?

(A) The fringes would become brighter.
(B) The position of the central bright fringe would change.
(C) The distance between dark fringes would increase.
(D) The distance between bright fringes would increase.
(E) The distance between bright fringes would decrease.

A16. Which one of the following wavelengths is typical of X-rays?

(A) 10^{-7} m (B) 1 cm (C) 10^{-11} m (D) 1 m (E) 10^{-5} m

A17. 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 on K-shell electrons.
(E) The cutoff wavelength occurs because an incident electron cannot give up all of its energy.

A18. During β^+ decay,
(A) an antineutrino is emitted.
(B) an alpha particle is emitted.
(C) an electron is emitted.
(D) a positron is emitted.
(E) a photon is emitted.

A19. Which one of the following particles has the **least** mass?
(A) electron (B) proton (C) neutron (D) positron (E) neutrino

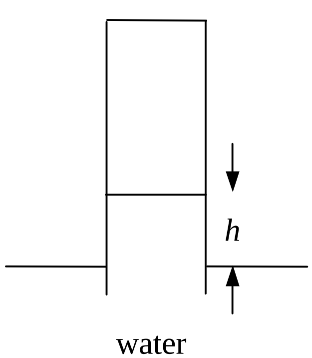
A20. Identify X in the following reaction: ${}^{235}_{92}\text{U} \rightarrow {}^{142}_{56}\text{Ba} + {}^{90}_{36}\text{Kr} + X$
(A) one alpha particle
(B) two alpha particles
(C) three protons
(D) three neutrons
(E) six neutrons

B1. A box of mass 2.25 kg is at rest on a horizontal surface. The coefficient of static friction between the box and the surface is 0.650. Calculate the minimum horizontal force required to move the box.

B2. A rope is pulling a box of mass 50.0 kg across a rough horizontal surface. The tension in the rope is 205 N and the rope makes an angle of 35.0° above the horizontal. Calculate the work done on the box by the rope as the box is pulled through a distance of 2.60 m.

B3. A uniform, solid, horizontal disk of mass 155 kg and radius 1.50 m is set in motion by wrapping a rope about the rim of the disk and pulling on the rope. Calculate the angular acceleration of the disk when the net torque acting on it is 338 N·m.

B4. A pipe, closed at one end, is held vertically with its open end submerged in a pool of water as shown in the diagram. If the air pressure in the pipe is reduced to one-quarter that of atmospheric pressure, to what height, h, will water rise in the pipe? (atmospheric pressure = 1.01×10^5 Pa, density of water = 1.00×10^3 kg/m^3)



B5. An object of mass 0.250 kg, attached to an ideal spring of spring constant 550 N/m, is moving in simple harmonic motion on a horizontal frictionless surface. The amplitude of the motion is 0.475 m. Calculate the speed of the object as it passes through the equilibrium position.

B6. A flashlight battery of emf 1.50 V has an internal resistance of 0.0550 Ω. Calculate the potential difference across its terminals when the battery is delivering a current of 2.00 A.

B7. A proton moves with a speed of 8.00×10^6 m/s and enters a magnetic field of magnitude 2.50 T directed at an angle of 60.0° to the initial velocity of the proton. Calculate the magnitude of the acceleration of the proton.

B8. A jeweller's loupe is a small magnifying glass (converging lens) that is held close to the eye. A particular loupe has a focal length of 4.00 cm. Calculate the distance from the loupe at which an object must be held (the object distance) so that a jeweller with a near point of 30.0 cm achieves maximum angular magnification.

B9. Calculate the wavelength of the $n = 4$ to $n = 2$ transition in a hydrogen atom. Express your answer in nm.

B10. Calculate the energy released in the following fusion reaction: $^{2}_{1}\text{H} + ^{2}_{1}\text{H} \rightarrow ^{4}_{2}\text{He}$
(Atomic masses: $m(^{2}_{1}\text{H}) = 2.014102$ u; $m(^{4}_{2}\text{He}) = 4.002603$ u)

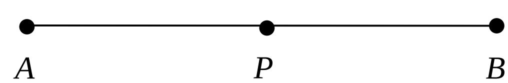
C1. A snowball of mass 0.125 kg is thrown at another snowball of mass 0.650 kg that is sitting on top of a post. The thrown ball has an initial speed of 22.0 m/s at an angle of 50.0° above the horizontal. The thrown ball is at its maximum height when it hits the ball on the post.

(a) Calculate the height of the thrown ball above its launch point when it hits the ball on the post.

(b) Calculate the speed of the thrown ball just before it hits the ball on the post.

(c) The collision between the two balls is completely inelastic. Calculate the speed of the balls immediately after the collision. Ignore any frictional effects between the balls and the post.

C2. Consider two point charges, *A* and *B*, separated by a distance of 1.20 m.
$q_A = -1.50 \times 10^{-6}$ C and $q_B = +4.20 \times 10^{-6}$ C



(a) Calculate the electric field (magnitude and direction) at point *P* midway between the charges. Specify direction as either toward *A* or toward *B*.

(b) Calculate the absolute electrostatic potential at point *P*.

(c) An electron is now released from rest at point *P*. Calculate the acceleration of the electron immediately after its release. Specify direction as either toward *A* or toward *B*. Ignore gravitational effects.

C3. Light falls on a diffraction grating which contains 3.18×10^4 lines/cm. An interference pattern is observed on a screen which is placed at a distance of 2.85 m from the grating.

(a) Calculate the wavelength of light which produces a second-order maximum at a location on the screen which is 2.47 m from the central maximum.

(b) Suppose a slit is cut into the screen at this point, so that only light of this wavelength passes through. This light then falls on a plate made of zinc. Calculate the maximum kinetic energy of the photoelectrons which are emitted from the zinc plate. The work function for zinc is 4.31 eV.

(c) The photoelectrons are accelerated towards an anode by a potential difference of 10,500 V. Calculate the minimum wavelength in the X-ray bremsstrahlung spectrum. *[Hint: the initial KE of the photoelectrons is negligible.]*