Questions from April 2001 Physics 111.6 Final Examination

A1. Which one of the following is **NOT** a unit of energy?

(A) W/s (B) N·m (C) J (D) eV (E) $kg \cdot m^2/s^2$

A2. Which one of the following is a vector quantity?

(A) mass (B) time (C) work (D) electric field (E) electric potential

A3. An object is dropped from rest from the top of a building. The object has fallen a distance *y* after one second. How far has the object fallen after two seconds? (Ignore any frictional effects.)

(A) 8*y* (B) 6*y* (C) 4*y* (D) 3*y* (E) 2*y*

A4. Which one of the following statements **must** be true regarding an object moving with constant velocity?

(A) The net force on the object is zero.
(B) There are no forces acting on the object.
(C) The object is in uniform circular motion.
(D) There is no frictional force acting on the object.
(E) The object is in simple harmonic motion.

A5. A conservative force acts on an object as it moves from location A to location B and back to location A. Which one of the following statements is correct concerning the work done by the conservative force?

The work done by the conservative force on the object moving from A to B to A
(A) is zero.
(B) depends on the path of the object.
(C) depends on the speed of the object.
(D) depends on the acceleration of the object.
(E) depends on the time required for the object to move from A to B to A.

A6. Which one of the following statements is correct?

In an elastic collision,
(A) both kinetic energy and momentum are conserved.
(B) momentum is conserved but kinetic energy is not.
(C) kinetic energy is conserved but momentum is not.
(D) the objects must move in opposite directions after the collision.
(E) the objects stick together after the collision.

A7. A motor connected to a solid disk causes the disk to rotate about a fixed axis with a steadily increasing angular velocity. At any instant, which one of the following quantities is the same for all points on the disk?

(A) Centripetal acceleration.
(B) Tangential acceleration.
(C) Total acceleration.
(D) Tangential speed.
(E) Angular acceleration.

A8. Which one of the following statements is correct?

The negative sign in Hooke's Law indicates that

(A) the force is always directed toward the equilibrium position.
(B) the force is always directed away from the equilibrium position.
(C) the force is always directed opposite to the acceleration of the object on which the force is acting.
(D) the magnitude of the force decreases as the displacement from the equilibrium position increases.
(E) the spring constant is a negative quantity.

A9. Assuming water is an incompressible fluid, what happens as a rock, dropped into a swimming pool, sinks towards the bottom?

As the rock sinks,

(A) the buoyant force on the rock increases and the pressure on the rock increases.
(B) the buoyant force on the rock increases and the pressure on the rock stays the same.
(C) the buoyant force on the rock increases and the pressure on the rock decreases.
(D) the buoyant force on the rock stays the same and the pressure on the rock increases.
(E) the buoyant force on the rock stays the same and the pressure on the rock stays the same.

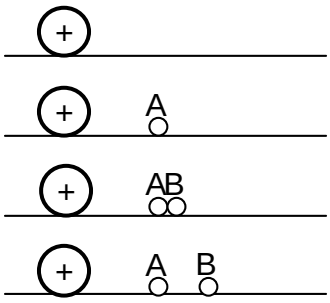
A10. A sound source has a frequency f. An observer listening to the sound is moving at a non-zero speed v_o, and the sound source is moving at a non-zero speed v_s. In which one of the following cases will the frequency heard by the observer be largest?

(A) The observer is moving toward the source, and the source is moving away from the observer.
(B) The observer is moving toward the source, and the source is moving toward the observer.
(C) The observer is moving away from the source, and the source is moving toward the observer.
(D) The observer is moving away from the source, and the source is moving away from the observer.
(E) The largest frequency can only be heard when the observer is stationary and the source is stationary.

A11. The sound intensity at a certain distance from a source is I. Assuming the sound radiates uniformly in all directions, what would be the sound intensity if the listener were twice as far away from the source?

(A) ¼ I (B) ½ I (C) 2 I (D) 4 I (E) 8 I

A12. A large positively charged object is placed on an insulating table. A neutral metal ball, A, is then placed near, but not touching, the object. A second neutral metal ball, B, is then placed so that it touches ball A, with ball A between the charged object and ball B. Ball B is then moved a bit further away from the charged object so that it is now not touching ball A. The balls are always moved with a hand wearing an insulating glove. The sequence of moves is shown in the diagram. Which statement is true concerning the final charge on each ball?



(A) Ball A is negatively charged and ball B is negatively charged.
(B) Ball A is negatively charged and ball B is positively charged.
(C) Ball A is positively charged and ball B is negatively charged.
(D) Ball A is positively charged and ball B is positively charged.
(E) Both balls remain neutral.

A13. The voltage of most home wall outlets is labelled 120 V. Which one of the following statements is correct?

(A) This is the rms voltage, and the peak voltage is $120\ \text{V} / \sqrt{2}$.
(B) This is the rms voltage, and the peak voltage is $120\ \text{V} \times \sqrt{2}$.
(C) This is the peak voltage, and the rms voltage is $120\ \text{V} / \sqrt{2}$.
(D) This is the peak voltage, and the rms voltage is $120\ \text{V} \times \sqrt{2}$.
(E) The rms voltage is 120 V, and the peak voltage is 120 V.

A14. The human eye is a remarkable optical device. Which one of the following statements is true regarding the image formed by the lens system of the human eye?

(A) A real inverted image is formed on the retina and the image is smaller than the object.
(B) A virtual inverted image is formed on the retina and the image is smaller than the object.
(C) A real upright image is formed on the retina and the image is larger than the object.
(D) A virtual upright image is formed on the retina and the image is larger than the object.
(E) A real upright image is formed on the retina and the image is smaller than the object.

A15. An object is placed in front of a single converging lens of focal length *f*. The image is observed to be real, inverted and reduced in size. The object distance must be

(A) negative.
(B) positive and less than *f*.
(C) positive and equal to *f*.
(D) positive and between *f* and 2*f*.
(E) positive and greater than 2*f*.

A16. In a Young's double slit experiment, green light is incident on the two slits and an interference pattern is produced on the screen. Which one of the following changes would cause the fringes to be more closely spaced?

(A) Move the screen further away from the slits.
(B) Move the light source further away from the slits.
(C) Reduce the separation of the slits.
(D) Use red light instead of green light.
(E) Use blue light instead of green light.

A17. Which one of the following is an accurate statement about photons?

(A) In a vacuum, ultraviolet photons travel faster than infrared photons.
(B) Photons do not have momentum.
(C) Photons can have either positive or negative charge.
(D) An ultraviolet photon has more energy than an infrared photon.
(E) When a photon travels from a vacuum into glass, its frequency decreases.

A18. $^{141}_{56}\text{Ba}$ is unstable and decays by β^- emission. A sample containing $^{141}_{56}\text{Ba}$ nuclei has an activity A_0 at a certain time. 36 minutes later we find that the sample's activity has decreased to $A_0/4$. The half life of $^{141}_{56}\text{Ba}$ is

(A) 9 minutes.
(B) 12 minutes.
(C) 18 minutes.
(D) 36 minutes.
(E) 72 minutes.

A19. The radioactive isotope $^{21}_{11}\text{Na}$ undergoes β^+ decay. What is the daughter nucleus?

(A) $^{21}_{10}\text{Ne}$ (B) $^{17}_{9}\text{F}$ (C) $^{20}_{11}\text{Na}$ (D) $^{22}_{11}\text{Na}$ (E) $^{21}_{12}\text{Mg}$

A20. Which one of the following statements best describes the process by which energy is produced in a nuclear fission reactor?

(A) The radiation given off by the naturally radioactive substance, uranium, is collected and used to make steam.
(B) Uranium reacts with oxygen in a combustion process that releases large amount of radioactivity and heat.
(C) Deuterium and tritium are joined together to form helium.
(D) Uranium, when bombarded by neutrons, is raised to an excited state. It then decays by emitting gamma rays, which are used to make steam.
(E) Uranium, when bombarded by neutrons, splits into fragments and releases energy.

B1. A football is kicked with an initial velocity of 22.0 m/s at an angle of 35.0° above the horizontal ground. Calculate the maximum height reached by the football. (Neglect air resistance.)

B2. A car of mass 1250 kg moving with a constant speed of 15.0 m/s goes around a flat horizontal curve. The radius of the curve is 95.0 m. Calculate the magnitude of the frictional force of the road surface on the car.

B3. An object of mass 1.25 kg moving with an initial speed of 6.15 m/s has a completely inelastic collision with a second object that is initially at rest. The speed of the objects after the collision is 2.50 m/s. Calculate the mass of the second object.

B4. An object of mass 1.50 kg on a horizontal frictionless surface is attached to a horizontal ideal spring with spring constant 225 N/m. The mass is undergoing simple harmonic motion and has a maximum kinetic energy of 3.16 J. Calculate the amplitude of the mass's motion.

B5. At a certain distance from a jet engine the sound intensity level (referenced to the threshold of hearing) is measured to be 125 dB. Calculate the sound intensity (in W/m^2) at this distance from the jet engine.

B6. In a Hydrogen atom the electron is normally at an approximate distance of 5.29×10^{-11} m from the proton. Calculate the magnitude of the electrostatic force on the electron when it is at this distance from the proton.

B7. A 25.0 Ω resistor and a 15.0 Ω resistor are connected in series across an ideal 6.00 V battery. Calculate the total current supplied by the battery.

B8. In a Young's double slit experiment, laser light with a wavelength of 605 nm is used with slits separated by 1.25×10^{-4} m. Calculate the angle at which the second-order bright fringe occurs.

B9. What wavelength photon is emitted when a singly-ionized helium (Z = 2) atom makes a transition from the n = 3 level to the n = 1 level?

B10. A sample initially contains 4.00×10^{18} atoms of a radioactive isotope with a half-life of 2.30 years. After 4.50 years, how many atoms of the radioactive isotope remain in the sample?

C1. The turntable of a merry-go-round is a solid uniform disk of mass 250 kg and radius 2.00 m. Standing on the edge of the merry-go-round is a child of mass 40.0 kg. The merry-go-round is initially at rest.

(a) Calculate the moment of inertia of the merry-go-round and child about the merry-go-round's axis of rotation.

(b) A motor now exerts a constant torque of 51.5 N·m on the merry-go-round for a time of 20.0 seconds. Ignoring any frictional effects, calculate the angular velocity of the merry-go-round (with the child) after the 20.0 s.

(c) After the 20.0 s mentioned in (b) above, the motor is turned off and the merry-go-round continues to rotate without friction. The child then walks towards the centre of the merry-go-round and stops a distance of 0.500 m from the axis of rotation. Calculate the new angular velocity of the merry-go-round.

C2. A steel wire of length 0.450 m and mass 2.80×10^{-3} kg is kept under a tension of 976 N.

(a) Calculate the speed at which transverse waves move along the wire.

(b) If the wire is fixed at both ends, calculate its fundamental frequency of vibration.

(c) The density of steel is 7860 kg/m^3. Calculate the cross-sectional area of the wire.

C3. Consider the nuclear reaction that is initiated when an α–particle is made to hit a $^{28}_{14}\mathrm{Si}$ nucleus:

$$^{4}_{2}\mathrm{He} + ^{28}_{14}\mathrm{Si} \rightarrow ^{A}_{Z}\mathrm{X} + ^{1}_{1}\mathrm{H}$$

Initially the $^{28}_{14}\mathrm{Si}$ nucleus is at rest and the α–particle has a kinetic energy of 12.00 MeV.
Some useful data:

Atomic mass of the Helium isotope $^{4}_{2}\mathrm{He}$ =	4.002603 u
Mass of an α–particle =	6.64×10^{-27} kg
Atomic mass of the Silicon isotope $^{28}_{14}\mathrm{Si}$ =	27.976927 u
Atomic mass of the unknown isotope $^{A}_{Z}\mathrm{X}$ =	30.973762 u
Atomic mass of the Hydrogen isotope $^{1}_{1}\mathrm{H}$ =	1.007825 u
Mass of a proton =	1.007276 u

(a) Find the mass number A, the atomic number Z, and the number of neutrons N in the unknown isotope $^{A}_{Z}\mathrm{X}$.

(b) Calculate the speed of the α–particle (in m/s) before it hits the $^{28}_{14}\mathrm{Si}$ nucleus.

(c) Calculate the Q–value of the reaction (in MeV).

(d) Calculate the sum of the kinetic energies of the unknown nucleus and the proton after the reaction (in MeV).