Questions from April 2003 Physics 111.6 Final Exam

A1. Which one of the following statements concerning scalars and vectors is **FALSE**?

(A) A vector quantity deals with magnitude and direction.
(B) The direction of an arrow representing a vector gives the direction of the vector.
(C) The length of an arrow representing a vector is proportional to the magnitude of the vector.
(D) If a quantity is always positive it must be a vector quantity.
(E) A scalar quantity does not include a direction.

A2. A ball is thrown straight up. For which point during its flight are **both** the instantaneous acceleration **and** the instantaneous velocity zero?

(A) On the way up.
(B) On the way down.
(C) At the highest point in its flight.
(D) At the highest point in its flight, but only if we neglect air resistance.
(E) There is no point during its flight where both are zero.

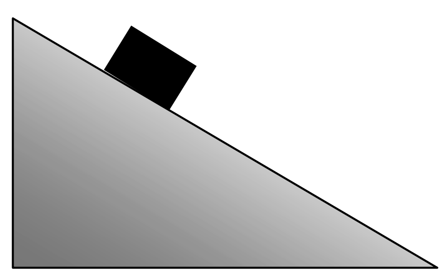
A3. Which one of the following expressions is dimensionally consistent with an expression for acceleration? x is a distance, t is a time, and v is a speed.

(A) $\frac{v}{t^2}$ (B) $\frac{v}{x^2}$ (C) $\frac{v^2}{t}$ (D) $\frac{v^2}{x}$ (E) $\frac{vx}{t}$

A4. A woman holds a 20 N shovel horizontally at rest. On the shovel is 16 N of dirt. She grips the shovel with one hand at the end of the handle and the other hand at the centre of gravity of the shovel. The <u>net vertical</u> force she exerts on the shovel is

(A) 20 N upward
(B) 4 N upward
(C) 36 N upward
(D) Zero.
(E) There is not enough information to know.

A5. In an experiment with a block of wood on an inclined plane, the following observations are made: (1) If the block is placed on the inclined plane, it remains there at rest. (2) If the block is given a small push, it accelerates towards the bottom without any further pushing. What conclusion can be drawn from these observations?



(A) The coefficient of kinetic friction must be negative.
(B) The coefficients of kinetic friction and static friction are equal.
(C) The coefficient of kinetic friction is larger than the coefficient of static friction.
(D) The coefficient of static friction is larger than the coefficient of kinetic friction.
(E) The coefficient of static friction is zero and the coefficient of kinetic friction is non-zero.

A6. A boy and a girl are riding on a merry-go-round that is turning. The boy is twice as far as the girl from the merry-go-round's axis of rotation. If the boy and girl are of equal mass, which one of the following statements is true about the boy's moment of inertia with respect to the axis of rotation?

(A) His moment of inertia is 4 times the girl's.
(B) His moment of inertia is twice the girl's.
(C) His moment of inertia is $\sqrt{2}$ times the girl's.
(D) The boy has the greater moment of inertia, but it is impossible to say exactly how much greater.
(E) The moment of inertia is the same for both.

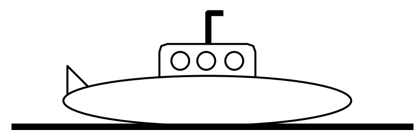
A7. A wheel of radius r is rolling without slipping with angular speed ω. The translational speed of the wheel's axis of rotation is

(A) $r\omega^2$ (B) $2r\omega$ (C) $\frac{1}{2}r\omega$ (D) $r\omega$ (E) $r^2\omega$

A8. Simple Harmonic Motion is characterized by

(A) a constant acceleration.
(B) an acceleration whose magnitude is proportional to the acceleration due to gravity.
(C) an acceleration whose magnitude is proportional to displacement from equilibrium.
(D) an acceleration whose magnitude is proportional to velocity.
(E) an acceleration whose magnitude is inversely proportional to velocity.

A9. A submarine rests on the sea floor, completely submerged. The magnitude of the normal force exerted on the submarine by the sea floor is equal to



(A) the buoyant force acting on the submarine less 1 atmosphere.
(B) the weight of the submarine plus the weight of the water displaced by the submarine.
(C) the weight of the submarine.
(D) the weight of the submarine less the weight of the water displaced by the submarine.
(E) the weight of the water displaced by the submarine.

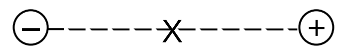
A10. Which one of the following properties of a sound wave is most closely identified with the 'pitch' of a musical note?

(A) Amplitude.
(B) Speed.
(C) Frequency.
(D) Phase.
(E) Intensity.

A11. Consider the fundamental frequency of an organ pipe that is initially open at both ends. When a cap is placed over one end of the organ pipe, the fundamental frequency will

(A) double.
(B) increase by 25%.
(C) not change.
(D) be halved.
(E) be a quarter of its original value.

A12. Two charges are separated by 1 metre. The charges have equal magnitudes but the charge on the left is negative while the charge on the right is positive. As one moves from the midpoint between the two charges towards the charge on the right, what happens to the electric potential, compared to the potential at the midpoint?



(A) The potential increases.
(B) The potential decreases.
(C) The potential stays the same.
(D) The potential drops to zero as you reach the charge on the right.
(E) The potential becomes twice as large as you reach the charge on the right.

A13. A charged particle is moving with a velocity that is perpendicular to a magnetic field. The effect of the magnetic field is to change the particle's

(A) mass.
(B) magnitude of momentum.
(C) speed.
(D) energy.
(E) direction of motion.

A14. A proton, initially at rest, is accelerated through an electric potential difference of 10 kV. After moving through the potential difference, the proton has a kinetic energy of

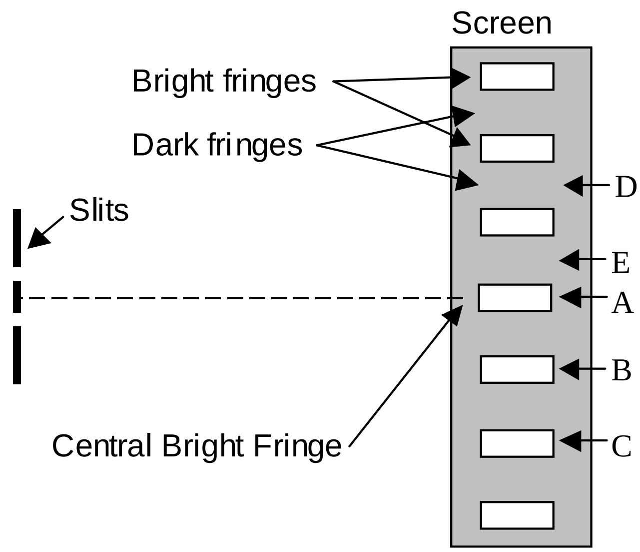
(A) 10 kJ (B) 10 kW (C) 10 kC (D) 10 keV (E) 10 kV

A15. Alyssa has a far point of 5 m. Which one of the following statements about Alyssa's vision 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.

A16. The figure shows the interference pattern observed on a screen in a double-slit experiment using light of wavelength 600 nm. Which fringe on the screen is 1200 nm further away from one of the slits than from the other slit?

(A) A
(B) B
(C) C
(D) D
(E) E



A17. Photons of energy 6 eV cause electrons to be emitted from the surface of a certain metal with a maximum kinetic energy of 2 eV. If photons with <u>twice the wavelength</u> are incident on the same metal, which one of the following statements is true?

(A) No electrons will be emitted.
(B) Electrons will be emitted with a maximum kinetic energy of 1 eV.
(C) Electrons will be emitted with a maximum kinetic energy of 8 eV.
(D) Electrons will be emitted with a maximum kinetic energy of 10 eV.
(E) Electrons will be emitted with a maximum kinetic energy of 20 eV.

A18. 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 ($n \rightarrow 3n$), the new radius is

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

A19. A freshly prepared sample contains N_0 radioactive nuclei that have a half life of 10 days. How many of these nuclei remain after 30 days?

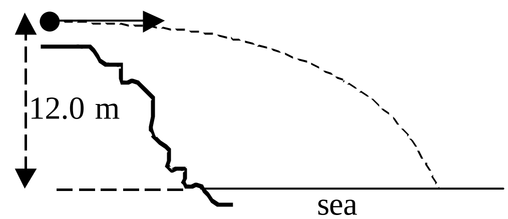
(A) $\frac{1}{2}N_0$ (B) $\frac{1}{3}N_0$ (C) $\frac{1}{4}N_0$ (D) $\frac{1}{8}N_0$ (E) $\frac{1}{9}N_0$

A20. What is the missing particle in the following nuclear reaction?

$$ {}^{2}_{1}\mathrm{H} + {}^{196}_{78}\mathrm{Pt} \rightarrow {}^{197}_{79}\mathrm{Au} + (?) $$

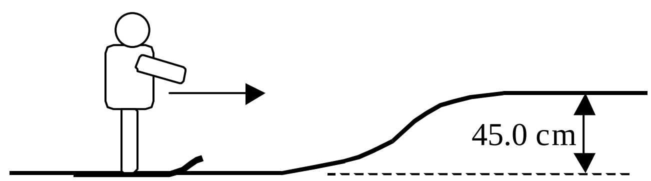
(A) An electron.
(B) An alpha particle.
(C) A neutron.
(D) A proton.
(E) A gamma ray.

B1. A stone is thrown horizontally from the top of a seaside cliff. Ignoring air resistance, calculate the time after release when the stone hits the sea, which is a vertical distance of 12.0 m below the point from which the stone was thrown.



B2. A fairground ride consists of chairs suspended by cables from a rotating pole as shown. The chair and a rider have a combined mass of 205 kg. As the chair is swung in a horizontal circular path, the cable makes an angle $\theta = 60.0°$ with the vertical. What is the tension in the cable?

B3. A skier is speeding along a horizontal snow surface at 3.20 m/s. She encounters a rise of height 45.0 cm. Ignoring friction with the snow and the air, calculate her speed on the horizontal surface at the top of the rise.



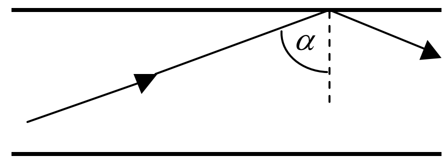
B4. Some children are riding on a merry-go-round which is rotating at an angular velocity of 1.19 rad/s. The children are near the edge of the merry-go-round and the moment of inertia of the system (children plus merry-go-round) is 305 kg·m^2. The children now move toward the centre of the merry-go-round and the moment of inertia of the system becomes 212 kg·m^2. Calculate the new angular velocity of the merry-go-round.

B5. A siren is radiating sound energy uniformly in all directions at a constant rate of 119 W. Calculate the sound intensity level (in dB) at a distance of 50.0 m from the siren.

B6. When a stretched rubber band, with length 0.0650 m, is fixed at both ends, it oscillates with a fundamental frequency of 425 Hz. What is the speed at which waves travel along this rubber band?

B7. A cylindrical cable carries a current of 1.20×10^{3} A. There is a potential difference of 1.50×10^{-2} V between two points on the cable that are separated by a distance of 0.200 m. The resistivity of the cable material is 1.72×10^{-9} Ω·m. What is the cross-sectional area of the cable?

B8. The index of refraction of a (simplified) optical fibre is 1.46 and that of the surrounding air is 1.00. What is the minimum incident angle α at which light can strike the side of the fibre so that it all remains within the fibre?



B9. Light from a laser, with wavelength 633 nm, is incident normally on a diffraction grating. A second order maximum is observed at an angle of 38.3° from the straight-ahead direction. Calculate the distance between adjacent lines in the diffraction grating.

B10. The electron in a helium ion He^+ ($Z = 2$) goes from the $n = 3$ orbit into the ground state. Calculate the wavelength (<u>in nm</u>) of the photon emitted during the transition.

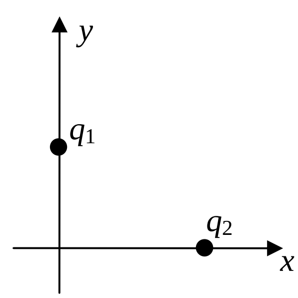
C1. An asteroid, with a mass of 4.50×10^{10} kg, is traveling at a speed of 5.00×10^3 m/s on a collision course with the Earth. A nuclear powered rocket is attached to the asteroid. When it is turned on it applies a force on the asteroid that is in the opposite direction to the velocity of the asteroid. After the rocket has burned for a fixed period of time the asteroid has been slowed to a speed of 2.60×10^3 m/s. (In the following ignore the mass of the rocket and its fuel.)

(a) What is the work done on the asteroid by the rocket force during this time period?

(b) During the time of the rocket burn the asteroid moved a distance of 5.50×10^4 m. What is the magnitude of the force applied by the rocket?

(c) A satellite is placed in a circular orbit around the asteroid to monitor its approach. The satellite must maintain an orbit that is 7.40×10^3 m above the center of gravity of the asteroid. Calculate the required orbital speed of the satellite.

C2. A charge $q_1 = +1.25\ \mu C$ is located at $x = 0$, $y = 0.250$ m and a charge $q_2 = +2.75\ \mu C$ is located at $x = 0.350$ m, $y = 0$.



(a) Calculate the absolute electrostatic potential at the origin.

(b) Calculate the electric field (magnitude and direction) at the origin. (Specify the direction as the counter-clockwise angle from the $+x$-axis direction.)

(c) Calculate the electric force (magnitude and direction) on an electron placed at the origin.

C3. The decay of a radioactive element can be used as a power source for an unmanned spacecraft that will venture far from the sun so that solar power is not enough. One possibility is to use the decay of ${}^{232}_{92}\mathrm{U}$, which has a half-life of 68.9 years. It decays by α–particle emission: ${}^{232}_{92}\mathrm{U} \rightarrow {}^{228}_{90}\mathrm{Th} + \alpha$.

$$\begin{aligned} \text{Atomic mass of } {}^{232}_{92}\mathrm{U} &= 232.037131 \text{ u} \\ \text{Atomic mass of } {}^{228}_{90}\mathrm{Th} &= 228.028716 \text{ u} \\ \text{Atomic mass of } {}^{4}_{2}\mathrm{He} &= 4.002602 \text{ u} \\ 1 \text{ year} &= 3.16 \times 10^{7} \text{ s} \end{aligned}$$

(a) Calculate the energy released (in MeV) when one atom of ${}^{232}_{92}\mathrm{U}$ decays.

(b) At the beginning of the spacecraft's mission, the radioactive sample initially contains 4.62×10^{22} atoms of ${}^{232}_{92}\mathrm{U}$. Calculate the activity (in Becquerel) of the sample at this time.

(c) Calculate the number of ${}^{232}_{92}\mathrm{U}$ atoms remaining at the end of a 30.0 year mission.

(d) Calculate the total energy released (in Joules), through the decay of ${}^{232}_{92}\mathrm{U}$, during the 30.0 year mission. [Hint: First find the energy in MeV.]

(e) Calculate the average power (in Watts) available from the decay of ${}^{232}_{92}\mathrm{U}$ during the 30.0 year mission.