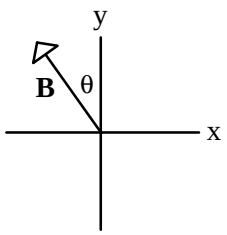
PHYSICS CONTEST EXAMINATION - 2008



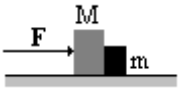
1. Vector **A** has components A_x, and A_y. Vector **B** has magnitude B and makes an angle of θ measured counter-clockwise with respect to the positive y axis as shown.

The x-component of the vector **A** – **B** is given by

(A) $A_x - B\cos\theta$ (B) $A_x + B\cos\theta$ (C) $B\sin\theta + A_x$ (D) $-B\sin\theta + A_x$
(E) none of the previous answers

2. A rock is thrown from ground level with a speed of v_o m/s at an angle of θ with respect to the horizontal. Let g represent the acceleration due to gravity. The distance the rock has traveled in the horizontal direction when it is at its highest point is given by

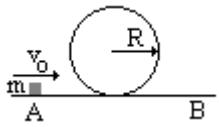
(A) $2 v_o^2 \cos\theta \sin\theta/g$ (B) $v_o^2 \sin\theta \cos\theta /g$ (C) $(v_o \sin\theta)^2/g$
(D) $(v_o \cos\theta)^2/g$ (E) none of the previous answers



3. Two blocks (mass M and mass m) are pushed along by a horizontal force F as shown.

The magnitude of the normal force of contact between the blocks is given by

(A) (m + M)/MF (B) (m + M)/mF (C) MF/(m + M)
(D) mF/(m + M) (E) none of the previous answers

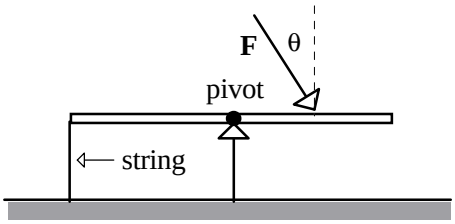


4. A mass m slides on a frictionless loop-the-loop of radius R as shown. The block is given a sufficient speed v_o at point A to go completely around the loop without losing contact with it.

The contact force that the loop exerts on mass m at the top of the track is given by

(A) mg (B) mv_o^2/R (C) $(mv_o^2/R) - 5mg$ (D) $mv_o^2/R - 3mg$
(E) none of the previous answers

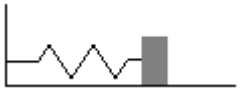
5. A uniform thin rod can rotate about a pivot fixed at its center as shown. The left end of the rod is tied to a string attached to the floor. A force F is applied at an angle of θ and keeps the rod in equilibrium while horizontal. F is applied L/4 from the right end. The mass of the rod is m and its overall length is L. Let g be the acceleration due to gravity.



The force the pivot exerts on the rod is given by

(A) $F \sin\theta - mg$ (B) $mg + F \sin\theta$ (C) $mg + F \cos\theta$ (D) $mg - F \cos\theta$
(E) none of the previous answers

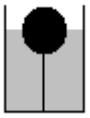
6. A mass m is attached to a spring whose natural length is L. The spring is stretched to a length of 1.5 L and released at time t = 0. The time for one complete oscillation is T.



The spring constant k is given by

(A) $4\pi^2 m/T$ (B) $(2\pi m)^2/T$ (C) $T/(4\pi^2 m)$ (D) $T/(2\pi m)^2$
(E) none of the previous answers

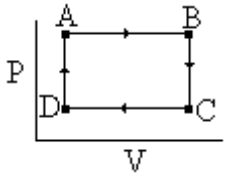
7. A hollow spherical shell has a mass m (including air inside) and radius R. It is held under water with half its volume submerged as shown. Note $V_{sphere} = (4/3)\,\pi\, R^3$ and let ρ_w be the density of water.



The tension T in the string is given by

(A) $mg - (4/3)g\pi R^3\rho_w$ (B) $-mg + (2/3)g\pi R^3\rho_w$ (C) $mg - (2/3)g\pi R^3\rho_w$
(D) $mg + (4/3)g\pi R^3\rho_w$ (E) none of the previous answers

8. 0.5 mole of an ideal gas undergoes the thermodynamic cycle shown. Use $P_D = P_C = P_o$ and $P_A = P_B = 3P_o$, $V_C = V_B = 4.0\ V_o$ and $V_A = V_D = V_o$.



The work done in one cycle is

(A) $3\ P_oV_o$ (B) $4.5\ P_oV_o$ (C) $6\ P_oV_o$ (D) $9P_oV_o$
(E) none of the previous answers

9. A speaker S whose intensity is 5.0×10^{-8} W/m^2 emits sound at a frequency 256 Hz. Point A represents a car with a listener in it.

S * A

In order for the listener to hear the highest frequency possible

(A) A and S should move away from one another (B) A should remain stationary and S should move toward A (C) S should remain stationary and A should move toward S
(D) A and S should move toward each other (E) A and S should remain stationary

10. Standing waves on a string are shown. The speed of the waves is v_o. The string has a length L. The amplitude is greatly exaggerated for clarity.

The wavelength for the case shown is

(A) L (B) (3/2)L (C) 3L (D) (2/3)L
(E) none of the previous answers

11. Work is most closely related to

(A) change in kinetic energy (B) change in total energy (C) change in potential energy
(D) change in linear momentum (E) change in angular momentum

12. A skater spins with angular velocity ω_o and moment of inertia I_o. Initially, she has kinetic energy K_o and angular momentum L_o. She pulls her arms in to reduce her moment of inertia to $I_o/2$. Her new kinetic energy is

(A) $K_o/4$ (B) $2K_o$ (C) $4K_o$ (D) $K_o/2$
(E) none of the previous answers

13. Bernoulli's principle is a statement of

(A) hydrostatic equilibrium (B) thermal equilibrium for fluids
(C) energy conservation in moving fluids (D) mechanical equilibrium for fluids
(E) momentum conservation for moving fluids

14. If a charge -Q is placed inside a hollow, isolated conductor having a wall thickness t that is originally neutral and the charge does not touch that conductor at any time

(A) the inside surface of the conductor will become positively charged.
(B) the outside surface of the conductor will become positively charged.
(C) both the inner and outer surfaces will remain neutral
(D) both the inner and outer surfaces will become negatively charged.
(E) none of the previous outcomes will occur.

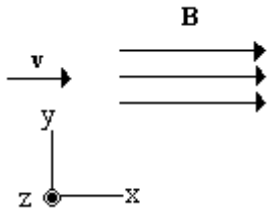
15. Two capacitors with capacitances of C_1 and C_2 are connected in series with a battery having an emf of E. The charge that accumulates on one plate of C_2 is

(A) E/C_2 (B)EC_2 (C) $EC_1C_2/(C_1+C_2)$
(D) $(C_1 + C_2)/EC_1C_2$ (E) none of the previous answers

16. Light that has a wavelength λ in vacuum travels in a material whose index of refraction is n. Let c be the speed of light in vacuum. Its wavelength in the material is

(A) $n\lambda$ (B) λ/n (C) $(n-1)\lambda$ (D) λ
(E) none of the previous answers

17. A magnetic field is along the +x direction as shown. A charge q enters the region with velocity **v**. The maximum magnetic force occurs



(A) only when **v** is along the x axis
(B) only when **v** is along the y axis
(C) only when **v** is along the z axis
(D) when **v** is along the x or z axis
(E) when **v** is along the y or z axis

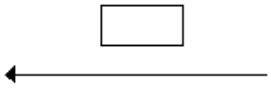
18. Linearly polarized light whose intensity is I_o passes through a polarizer whose transmission axis makes an angle θ with respect to the electric field of the light. If the intensity of the wave after passing through the linear polarizer is f I_o,where f is between zero and 1, the angle θ is

(A) arccos (f) (B) arccos (1/f) (C) arccos $(f)^{1/2}$ (D) arccos $(1/f)^{1/2}$
(E) none of the previous answers

19. Diamond has an index of refraction n_d. If a diamond is immersed in oil having an index of refraction n_o, where $n_o < n_d$, the critical angle for total internal reflection is

(A) arctan (n_o/n_d) (B) arctan (n_d/n_o) (C) arcsin (n_d/n_o)
(D) arcsin (n_o/n_d) (E) none of the previous answers

20. A long straight wire is in the same plane as a non-conducting loop. The wire carries a decreasing current in the direction shown. The correct statement concerning this situation is



(A) there will be no induced emf
(B) there will be a clockwise induced emf, but no induced current

(C) there will be an induced current that is clockwise around the loop
(D) there will be a counter-clockwise induced emf, but no induced current
(E) none of the previous statements

21. Two wires, A and B, and a variable resistor, R, are connected in series to a battery. If the resistance R is decreased,

(A) the current through A and B will increase
(B) the potential difference across A and B will increase
(C) the potential difference across the entire circuit will increase
(D) the power dissipated in R decreases
(E) none of the previous outcomes occur

22. The photon energy in a light beam is E. Let h be Planck's constant and c be the speed of light in a vacuum. The wavelength of a photon in the beam is given by

(A) h/cE (B) hc/E (C) hcE (D) E/hc
(E) none of the previous answers

23. An electron with mass m and charge q is accelerated to a speed v through a potential difference V. Let h be Planck's constant and assume $v<<c$. Its de Broglie wavelength is given by

(A) $h/(qmV)^{1/2}$ (B) $(qmV)^{1/2}/h$ (C) $h/(2qmV)^{1/2}$ (D) $(2qmV)^{1/2}/h$
(E) none of the previous answers

24. If a fossil bone contains 1/8th as much Carbon-14 as the bone of a living animal, the approximate age of the fossil is in terms of the half-life $T_{1/2}$ of Carbon-14 is given by

(A) $8T_{1/2}$ (B) $2T_{1/2}$ (C) $3T_{1/2}$ (D) $T_{1/2}/8$
(E) none of the previous answers

25. The main force responsible for holding ordinary matter together is

(A) the strong nuclear force (B) the weak nuclear force (C) the gravitational force
(D) the electromagnetic force (E) none of the previous answers