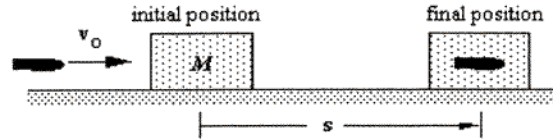


6. A bullet of mass m is fired at speed v_0 into a wooden block of mass M . The bullet instantaneously comes to rest in the block. The block with the embedded bullet slides along a horizontal surface with a coefficient of kinetic friction μ .



Which one of the following expressions determines how far the block slides before it comes to rest (the magnitude of displacement s in the figure)?

- A) $\frac{v_0^2}{\mu g}$
- B) $\left(\frac{m}{m+M}\right)^2 \frac{v_0^2}{2\mu g}$
- C) $\left(\frac{m}{m+M}\right)^2 \sqrt{\frac{v_0^2}{2\mu g}}$
- D) $\frac{mv_0^2}{M\mu g}$
- E) $\left(\frac{m}{m+M}\right) \frac{v_0^2}{\mu g}$

7. If the temperature of an ideal gas contained in a box is increased:
- A) the distance between molecules in the box will be increased.
- B) the average speed of the molecules in the box will be increased.
- C) the number of molecules in the box will be increased.
- D) the average time between collisions will be increased.
- E) the average velocity of the molecules in the box will be increased.

8. A tungsten filament of a lightbulb has an operating temperature of about 1800 °C. If the emitting area of the filament is 1 cm², and its emissivity is 0.68, what is the power output of the lightbulb? ($\sigma = 5.67 \times 10^{-8} \text{ W/m}^2 \text{ K}^4$)
- A) 60 W
 - B) 100 W
 - C) 40 W
 - D) 70 W
 - E) 150 W
9. A European sports car dealer claims that his product will accelerate at a constant rate from rest to a speed of 100 km/hr in 8 s. What is the speed after the first 5 s of acceleration?
- A) 17.4 m/s
 - B) 53.2 m/s
 - C) 44.4 m/s
 - D) 34.7 m/s
 - E) 28.7 m/s
10. Arvin the Ant is on a picnic table. He travels 30 cm eastward, then 25 cm northward and finally 15 cm westward. What is the magnitude of Arvin's net displacement?
- A) 70 cm
 - B) 29 cm
 - C) 57 cm
 - D) 52 cm
 - E) 42 cm
11. An airplane of mass 1.2×10^4 kg tows a glider of mass 0.6×10^4 kg. The airplane propellers provide a net forward thrust of 3.6×10^4 N. What is the glider's acceleration?
- A) 6.0 m/s²
 - B) 9.8 m/s²
 - C) 2.0 m/s²
 - D) 4.0 m/s²
 - E) 3.0 m/s²

12. A 100 kg cannon at rest contains a 10 kg cannon ball. When fired, the cannon ball leaves the cannon with a speed of 90 m/s. What is the recoil speed of the cannon?
- A) 4.5 m/s
 - B) 90 m/s
 - C) 45 m/s
 - D) zero
 - E) 9 m/s
13. A physics student standing on the edge of a cliff throws a stone vertically *downward* with an initial speed of 10 m/s. The instant before the stone hits the ground below, it is traveling at a speed of 30 m/s. If the physics student were to throw the rock *horizontally outward* from the cliff instead, with the same initial speed of 10 m/s, how fast would the stone be traveling just before it hits the ground?
- A) 20 m/s
 - B) 40 m/s
 - C) The height of the cliff must be specified to answer this question.
 - D) 10 m/s
 - E) 30 m/s
14. The coefficient of linear expansion of steel is $12 \times 10^{-6}/\text{C}^\circ$. A railroad track is made of single rails of steel 1.0 km in length. By what length would these single rails change between a cold day when the temperature is -10°C and a hot day at 30°C ?
- A) 0.62 cm
 - B) 24 cm
 - C) 48 cm
 - D) 620 cm
 - E) 480 cm
15. A rope of length L is clamped at both ends. Which one of the following is not a possible wavelength for standing waves on this rope?
- A) $2L/3$
 - B) $2L$
 - C) L
 - D) $4L$
 - E) $L/2$

16. In which one of the following situations is linear momentum *not conserved*?
- A) A golf ball is struck by a club.
 - B) A bomb suspended by a string explodes into one hundred fragments.
 - C) An astronaut floating in space throws a hammer away and subsequently moves in the opposite direction.
 - D) A tree limb is struck by lightning and falls to the ground.
 - E) A bowling ball collides with ten pins.

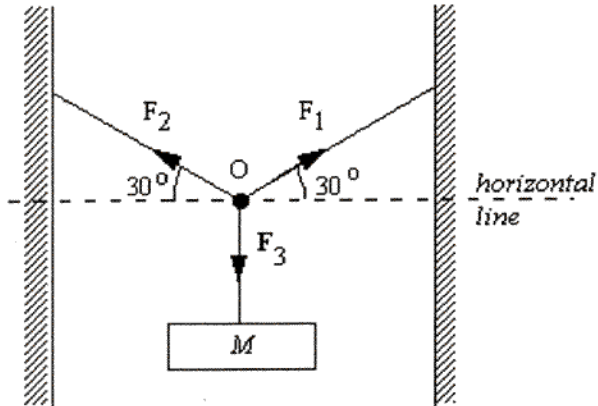
This question should say not counting the momentum of the earth.

17. A periodic wave is produced on a stretched string. Which one of the following properties is *not* related to the speed of the wave?
- A) amplitude
 - B) tension in the string
 - C) period
 - D) wavelength
 - E) frequency
18. Two boys are whispering in the library. The radiated sound power from one boy's mouth is $1.2 \times 10^{-9} \text{ W}$; and it spreads out uniformly in all directions. What is the minimum distance the boys must be away from the librarian so that she will not be able to hear them? The threshold of hearing for the librarian is $1.00 \times 10^{-12} \text{ W/m}^2$.
- A) 16 m
 - B) 35 m
 - C) 23 m
 - D) 9.8 m
 - E) 100 m
19. A solid sphere of uniform density and radius R rotates about a diameter with an angular speed ω . The sphere then collapses under the action of internal forces to a new uniform density and final radius $R/2$. What is the final angular speed of the sphere?
- A) $\omega/2$
 - B) $\omega/4$
 - C) 4ω
 - D) ω
 - E) 2ω

20. Which would cause a more serious burn: 30 g of steam or 30 g of liquid water, both at 100 °C; and why is this so? (The specific heat of water is 4186 J/(kg °C). The specific heat of steam is 2010 J/(kg °C). The latent heat of vaporization is 2.26×10^6 J/kg.)
- A) Steam, because of its latent heat of vaporization.
 - B) Steam, because of its specific heat.
 - C) Either one would cause a burn of the same severity since they are both at the same temperature.
 - D) Water, because it is more dense than steam.
 - E) Water, because its specific heat is greater than that of steam.
21. A rock is thrown straight up from the earth's surface. Which one of the following statements concerning the *net force* acting on the rock at the top of its path is true?
- A) It is instantaneously equal to zero.
 - B) It is greater than the weight of the rock.
 - C) It is equal to the weight of the rock.
 - D) It is less than the weight of the rock, but greater than zero.
 - E) Its direction changes from up to down.
22. Two canoes are 10 m apart on a lake. Each bobs up and down with a period of 4.0 seconds. When one canoe is at its highest point, the other canoe is at its lowest point. Both canoes are always within a single cycle of the waves. Determine the speed of the waves.
- A) 40 m/s
 - B) 80 m/s
 - C) 14 m/s
 - D) 2.5 m/s
 - E) 5.0 m/s
23. A 1.0-kg object is suspended from a spring with $k = 16$ N/m. The mass is pulled 0.25 m downward from its equilibrium position and allowed to oscillate. What is the maximum kinetic energy of the object? Ignore the gravitational potential energy.
- A) 0.25 J
 - B) 1.0 J
 - C) 4.0 J
 - D) 2.0 J
 - E) 0.50 J

24. Which one of the following statements must be true if the expression $x = v_0t + \frac{1}{2}at^2$ is to be used?
- A) x is constant.
 - B) a is constant.
 - C) v is constant.
 - D) Both v_0 and t are constant.
 - E) t is constant.
25. Young's modulus of nylon is 5×10^9 N/m². A force of 5×10^5 N is applied to a 2-m length of nylon of cross sectional area 0.1 m². By how much does the nylon stretch?
- A) 2×10^{-5} m
 - B) 2×10^{-1} m
 - C) 2×10^{-2} m
 - D) 2×10^{-4} m
 - E) 2×10^{-3} m
26. A rock is dropped from a high tower and falls freely under the influence of gravity. Which one of the following statements is true concerning the rock as it falls?
- A) It will gain an equal amount of momentum during each second.
 - B) It will gain an equal amount of momentum for each meter through which it falls.
 - C) The amount of momentum it gains will be proportional to the amount of potential energy that it loses.
 - D) It will gain an equal amount of speed for each meter through which it falls.
 - E) It will gain an equal amount of kinetic energy during each second.

27. A block of mass M is hung by ropes as shown.



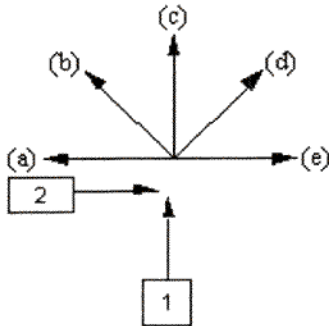
The system is in equilibrium. The point O represents the knot, the junction of the three ropes. Which of the following statements is true concerning the magnitudes of the three forces in equilibrium?

- A) $F_1 > F_3$
- B) $F_1 = F_2 = \frac{F_3}{2}$
- C) $F_1 = F_2 = F_3$
- D) $F_2 < F_3$
- E) $F_2 = 2F_3$

28. A boy is whirling a stone around his head by means of a string. The string makes one complete revolution every second, and the tension in the string is F_T . The boy then speeds up the stone, keeping the radius of the circle unchanged, so that the string makes two complete revolutions every second. What happens to the tension in the string?

- A) The tension increases to four times its original value.
- B) The tension reduces to half of its original value.
- C) The tension increases to twice its original value.
- D) The tension reduces to one-fourth of its original value.
- E) The tension is unchanged.

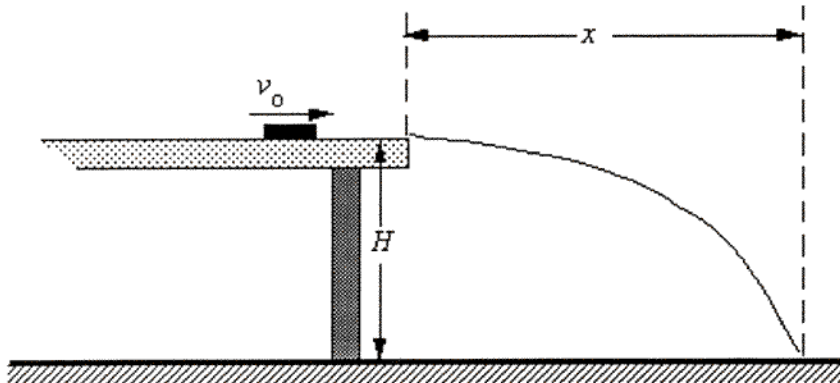
29. Car One is traveling due north and Car Two is traveling due east. After the collision shown, Car One rebounds due south. Which of the lettered arrows is the only one which can represent the final direction of Car Two?



30. How much power is needed to lift a 75-kg student vertically upward at a constant speed of 0.33 m/s?
- A) 25 W
 - B) 12.5 W
 - C) 243 W
 - D) 115 W
 - E) 230 W
31. A fountain sends water to a height of 100 meters. What must be the pressure (above atmosphere) of the underground water system?
- A) 9.7 Atm
 - B) 4.2 Atm
 - C) 10.7 Atm
 - D) 1 Atm
 - E) 7.2 Atm

32. Two vectors **A** and **B** are added together to form a vector **C**. The relationship between the magnitudes of the vectors is given by: $A + B = C$. Which one of the following statements concerning these vectors is true?
- A) **A** and **B** must be displacements.
 - B) **A** and **B** must have equal lengths.
 - C) **A** and **B** must point in opposite directions.
 - D) **A** and **B** must point in the same direction.
 - E) **A** and **B** must be at right angles to each other.
33. Using the value of atmospheric pressure at sea level, 1×10^5 Pa, estimate the total mass of the earth's atmosphere above a 5-m^2 area.
- A) 5×10^4 kg
 - B) 9×10^2 kg
 - C) 3×10^5 kg
 - D) 2×10^{-4} kg
 - E) 4×10^{-2} kg

34. A puck slides across a smooth, level tabletop at height H at a constant speed v_0 . It slides off the edge of the table and hits the floor a distance x away as shown in the figure.



What is the relationship between the distances x and H ?

- A) $x = v_0 \sqrt{\frac{2H}{g}}$
B) $x = \frac{v_0^2}{2gH}$
C) $x = \frac{v_0^2}{gH}$
D) $H = v_0 \sqrt{\frac{2x}{g}}$
E) $x = v_0 \frac{H}{g}$

35. Argon gas at 305 K is confined within a constant volume at a pressure P_1 . If the gas has a pressure P_2 when it is cooled to 195 K, what is the ratio of P_2 to P_1 ?
- A) 0.410
B) 0.717
C) 0.639
D) 1.28
E) 1.56