

1. A water line (the “main” line) enters a house at ground level. A smaller diameter pipe carries water to a faucet 4.0 m above ground, on the second floor. Water flows at 2.0 m/s in the main line. The pressure in the pipe on the second floor is lower than the ground floor water pressure by 6.8×10^4 Pa. What is the speed of the water on the second floor, in m/s? Assume the density of water is 1000 kg/m^3 .
 - A) 7.85
 - B) 7.12
 - C) 6.84
 - D) 5.04
 - E) None of these

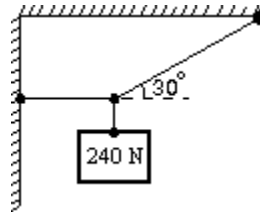
2. A 0.20-kg object mass attached to a spring whose spring constant is 500 N/m executes simple harmonic motion. If its maximum speed is 5.0 m/s, what is the potential energy (in J) when the speed is 2.5 m/s?
 - A) 1.25
 - B) 2.50
 - C) 1.88
 - D) 2.14
 - E) None of these

3. An oscillator creates a traveling wave on a string, described by $y(x,t) = 0.1 \sin(\pi x/2 - 10t)$, where x is in meters, y is in centimeters and t is in seconds. The frequency, f , of the oscillator, in hertz, is:
 - A) 4.50
 - B) 8.66
 - C) 4.56
 - D) 1.59
 - E) None of these

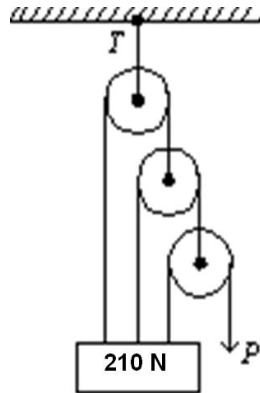
4. A column of a certain gas is open at one end, closed at the other. The shortest length of such a column that will resonate with a 600 Hz tuning fork is 0.49 m. The speed of sound (in m/s) in the gas must be about:
 - A) 90
 - B) 280
 - C) 560
 - D) 1180
 - E) None of these

5. Two speakers 14 m apart are emitting tones in phase at a frequency of 1700 Hz. A listener stands midway between the two speakers. What is the least distance (in m) the listener must move toward one speaker (or the other) in order to hear *minimum* sound? Assume the speed of sound is 340 m/s.
- 2.5
 - 1.50
 - 1.25
 - 0.5
 - none of these
6. The difference in decibel levels at two different points, $\beta_2 - \beta_1$, is 1.0 dB. What is the ratio of sound intensities, I_2/I_1 ?
- 1.03
 - 1.26
 - 1.38
 - 1.40
 - None of these
7. A uniform, solid metal block resting at the bottom of a pool of water has a height of 0.30 m, and is 0.40 m long, and 0.20 m wide. The contact force between the block and the bottom of the pool is 500 N. What is the density of the metal, in kg/m^3 ?
- 4426
 - 1890
 - 2345
 - 3126
 - None of these
8. A wheel, initially rotating at 37.50 rad/s, slows down and stops in 30 s. Through how many radians does the wheel turn during its last one second of motion?
- 0.625
 - 1.250
 - 2.500
 - 3.750
 - None of these
9. A uniform disk has a radius R and mass M . When it is spinning with angular velocity ω about an axis through its center, its rotational kinetic energy is K_0 . When it is spinning with the same angle velocity about a parallel axis a distance $2h$ from the central axis, the new rotational kinetic energy, K , is greater than K_0 by the amount:
- $2Mh^2\omega^2$
 - $(4MR^2 - 2Mh^2)\omega^2$
 - $(MR^2 - 1/2Mh^2)\omega^2$
 - $(1/2MR^2 - 4Mh^2)\omega^2$
 - None of these

10. When a man with horizontally-outstretched arms on a frictionless rotating stool retracts his arms, the rotational kinetic energy of the system:
- A) increases
 - B) decreases
 - C) remains the same
 - D) not enough information to determine
 - E) may either increase, or decrease, depending on the relative rotational inertias of stool and man
11. A 240-N weight is hung from two ropes as shown. The tension (in N) in the vertical rope from which the weight is hanging has magnitude:



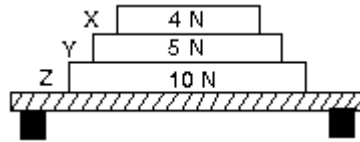
- A) 345
 - B) 656
 - C) 480
 - D) 416
 - E) 240
12. The pull P is just sufficient to keep the 210-N block and the weightless pulleys in equilibrium as shown. The tension T in the upper cable, in N, is:



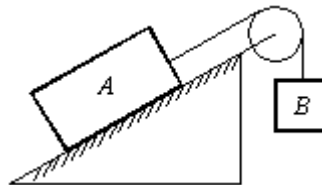
- A) 240
- B) 30
- C) 180
- D) 1440
- E) 210

13. A cube with edges exactly 2 cm long is made of material with a bulk modulus of $3.5 \times 10^9 \text{ N/m}^2$. When it is subjected to a pressure of $3.0 \times 10^5 \text{ Pa}$ its volume (in cm^3) is:
- A) 7.99045
 - B) 7.99931
 - C) 8.00069
 - D) 8.00042
 - E) none of these
14. A planet orbiting the sun has a mass of about 1.3 times the mass of Earth . The acceleration (in m/s^2) of a body falling near the surface of this planet is 8.9 m/s^2 . What is the ratio of this planet's radius to Earth's radius?
- A) 1.2
 - B) 1.4
 - C) 1.6
 - D) 1.8
 - E) None of these
15. A 5-kg block is pushed across a floor by a force of 40 N directed at an angle of 22° below the horizontal. The coefficient of kinetic friction between the floor and the block is 0.15. What is the acceleration of the block, in m/s^2 ?
- A) 2.12
 - B) 3.47
 - C) 4.22
 - D) 5.50
 - E) None of these
16. A 90-kg man stands in an elevator that is moving up at a constant speed of 5.0 m/s. The force (in N) exerted by him on the floor is about
- A) zero
 - B) 90
 - C) 880
 - D) 450
 - E) None of these

17. Three books (X, Y, and Z) rest on a table. The weight of each book is indicated. The force (in N) of book Z on book Y is:



- A) 0
 B) 5
 C) 9
 D) 10
 E) 19
18. A 10-kg crate rests on a horizontal surface and a boy pulls on it with a 40 N force that is directed at some angle above the horizontal. If the coefficient of static friction is 0.25, the angle (in degrees) along which he must pull in order to start the block moving is about: (Warning: if you use the “solver” feature, your calculator will provide *two* different answers, one negative, and one positive, depending on what starting value you input for x . You must reject the negative answer in favor of the positive one.)
- A) 44
 B) 47
 C) 54
 D) 68
 E) None of these
19. Block A, with a mass of 10 kg, rests on a 41° incline. The coefficient of static friction is 0.33. An attached string is parallel to the incline and passes over a massless, frictionless pulley at the top. The smallest mass m of block B (in kg), for which A remains at rest, rather than begin to slide down the plane, is (in kg):



- A) 3.11
 B) 3.54
 C) 4.07
 D) 5.08
 E) None of these

20. A mass of 4 kg, is moving to the right at a velocity of 2.0 m/s, collides head-on elastically with an object of mass 5 kg that is moving in the opposite direction with a velocity of -3 m/s. What is the velocity of the 4-kg mass after collision?
- A) 0.80
 - B) -1.12
 - C) -2.34
 - D) -3.56
 - E) None of these
21. During a four-second period of time, the speed of a 6-kg mass increases from 4.0 m/s to 7.5 m/s. What net impulse (in N-s) was delivered to the mass during this time?
- A) 13.5
 - B) 19.0
 - C) 21.
 - D) 32.8
 - E) None of these
22. A 1.5 kg object located 2.0 m above a spring whose spring constant is 1.5×10^3 N/m. The object is dropped and falls onto the spring. What will be the compression (in m) of the spring when the speed of the object is been reduced to 1.0 m/s?
- A) 0.043
 - B) 0.096
 - C) 0.136
 - D) 0.348
 - E) None of these
23. A car traveling at a certain initial speed begins to decelerate, gaining speed at the rate of 4 m/s^2 . During the next six seconds the car travels 240 m. What was the car's initial speed, in m/s?
- A) 28
 - B) 32
 - C) 40
 - D) 52
 - E) None of the above
24. While accelerating at a constant rate, an automobile's speed is increased from 43 m/s to 17 m/s. During this time period, the car travels 300 m. What will be its speed (in m/s) after five more seconds?
- A) 2.4
 - B) 8.1
 - C) 6.4
 - D) 4.0
 - E) None of the above

25. At time $t = 0$, an object moving at 2.0 m/s begins accelerating along the x-axis according to the equation, $\mathbf{a} = 2\mathbf{t} + 3\mathbf{e}^t$, where \mathbf{a} is in m/s^2 , and \mathbf{t} is in seconds. What distance (in m) does the object travel between $t = 1.0$ s and $t = 2.0$ s?

- A) 4.56
- B) 6.70
- C) 12.78
- D) 18.35
- E) None of the above

26. An object of mass $m = 4$ kg is moving along the x-axis according to the equation, $\mathbf{x} = 3 + 5\mathbf{t} + 4\mathbf{t}^3$, where \mathbf{x} is in m, and \mathbf{t} is in seconds. What total work (in J) will have been done on the object between times $t = 1.0$ s and $t = 1.4$ s?

- A) 17.80
- B) 23.04
- C) 34.56
- D) 19.87
- E) None of the above

27. The coordinates of an 5-kg object moving in a plane are $\mathbf{x} = 10\mathbf{t}^2$ and $\mathbf{y} = 2\mathbf{t}^3$, where \mathbf{x} and \mathbf{y} are in meters, and \mathbf{t} is in seconds. What is the magnitude of the approximate force on the object (in N) at $t = 2$ seconds?

- A) 86
- B) 156
- C) 211
- D) 92
- E) None of the above

28. The x, y, and z components of a vector \mathbf{A} are $\langle -3, 2, 1 \rangle$, and the components of a vector \mathbf{B} are $\langle 2, -2, 2 \rangle$. What is the angle (in degrees) between these two vectors?

- A) 44.56
- B) 128.11
- C) 104.86
- D) 24.35
- E) None of the above

29. An object's speed changes uniformly from 80 m/s to 190 m/s during a five-second time period. What will be its speed (in m/s) two seconds later, assuming the acceleration remains the same?

- A) 200
- B) 212
- C) 224
- D) 234
- E) None of the above

30. An airplane is traveling in air whose wind velocity with respect to the ground is 30 m/s, on a heading of 190° . The airplane's speed with respect to the air is 220 m/s, and its heading is 42° . What is the airplane's approximate speed with respect to the ground, in m/s?

- A) 221
- B) 195
- C) 213
- D) 204
- E) None of the above

31. A football is kicked over level ground at initial speed 25 m/s at an angle of 29 degrees above the horizontal. How high (in m) above the ground will the ball be 0.40 seconds before it strikes the ground?

- A) 3.65
- B) 4.06
- C) 5.11
- D) 0.56
- E) None of the above

32. A bucket of water is pushed from right to left with constant speed across a horizontal surface. Consider the pressure at two points at the same level in the water.

- A) It is the same
- B) It is higher at the point on the left
- C) It is higher at the point on the right
- D) At first it is higher at the point on the left but as the bucket speeds up it is lower there
- E) At first it is higher at the point on the right but as the bucket speeds up it is lower there

33. A 600-N block is floating one-third in water, and two-thirds out of water. What is the buoyant force on the block, in newtons?
- A) 600
 - B) 400
 - C) 200
 - D) Not enough information is provided
 - E) None of the above