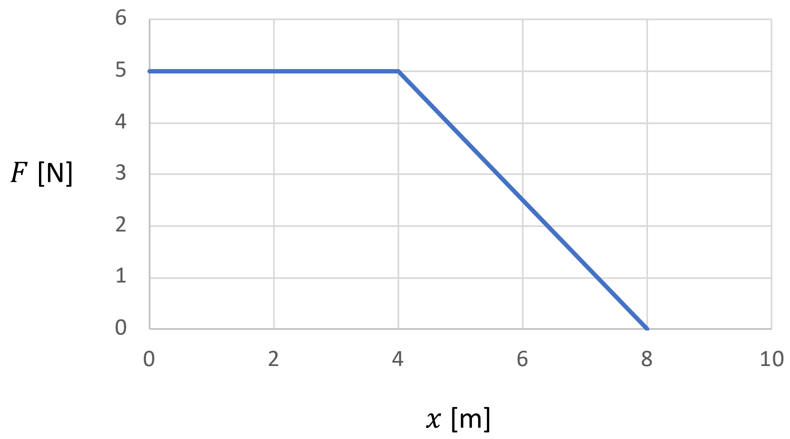
1. A cart of mass $6\ \mathrm{kg}$, initially at rest at the point of abscissa $x = 0$, is subjected to a force F which sets it in motion.



What is the speed of the cart at the point of abscissa $x = 8\ \mathrm{m}$?

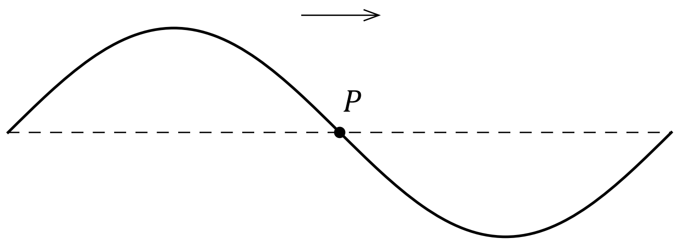
a. $2.5\ \mathrm{m/s}$
b. $3.0\ \mathrm{m/s}$
c. $3.2\ \mathrm{m/s}$
d. $3.6\ \mathrm{m/s}$

2. In an accelerating lift, Mr Martin stands on a bathroom scale. The mass of Mr Martin in his work clothes is $80\ \mathrm{kg}$. The scale shows $68\ \mathrm{kg}$.

What is the best estimate for lift acceleration?

a. $1.2\ \mathrm{m/s^2}$ upwards
b. $1.5\ \mathrm{m/s^2}$ upwards
c. $1.2\ \mathrm{m/s^2}$ downwards
d. $1.5\ \mathrm{m/s^2}$ downwards

3. A wave propagates along a string from left to right. The figure shows a point P on the string at a given moment.



Which of the statements about the value and direction of the velocity of the point P at this moment is correct?

a. Maximum value, pointing upwards
b. Minimum value, pointing upwards
c. Maximum value, pointing downwards
d. Minimum value, pointing downwards

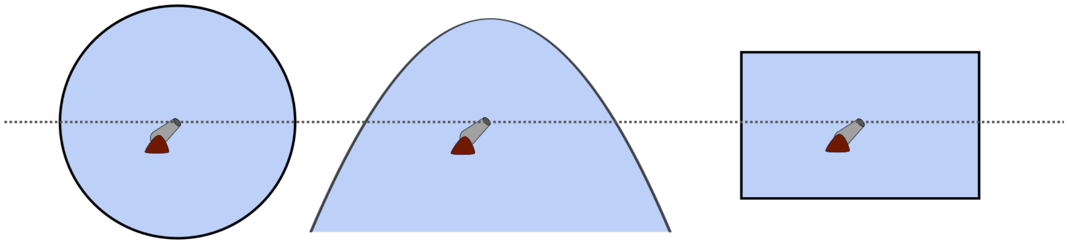
4. A driver applies a force of 200 N on the brake pedal. The result is a force of 40000 N on the brake discs. Assuming that this is an ideal frictionless hydraulic system, select the correct statement:

a. The work done by the driver is increased using the hydraulic system.
b. The distance traveled by the foot is 200 times greater than the distance traveled by the brake pads.
c. This is not possible because of the conservation of energy.
d. The ratio of the diameters of the hydraulic pistons is 200.

5. A small fish swims in its aquarium with a volume of $2\ \mathrm{L}$ and swims around with a constant speed of $0.5\ \frac{\mathrm{m}}{\mathrm{s}}$. The fish feels a frictional force of $1\ \mathrm{N}$. As the aquarium is well insulated, the temperature starts to rise. How much will the temperature rise after 1 hour, assuming that friction is the only source of heat? $\left(c_{\mathrm{water}} = 4.2\ \frac{\mathrm{J}}{\mathrm{gK}}\right)$

a. 0.21 K
b. 210 K
c. 12 K
d. 0.012 K

6. A cannon can fire balls with a given initial velocity v_0. Suppose that the angle of fire α can be changed at will without changing the starting position of the ball as it leaves the barrel. Then the location of the points that can be reached by a cannonball corresponds to:



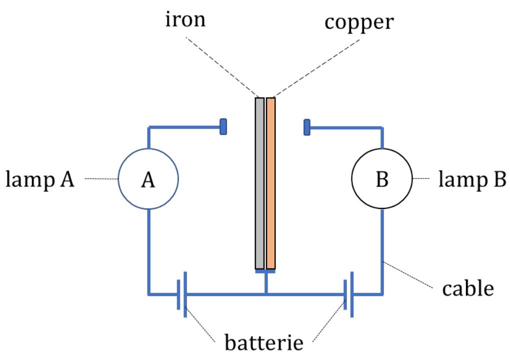
a. A disc with a radius $r = \frac{v_0^2}{2g}$ centred on the barrel

b. The surface below an inverted parabola of height $h = \frac{v_0^2}{2g}$

c. A rectangle with a diagonal $d = \frac{v_0^2}{4g}$

d. Impossible to determine without further information

7. The following diagram shows an open circuit. The circuit consists of two batteries, cables, 2 lamps (A and B) and a bimetal. The bimetal is then heated by external heat. Which scenario will occur?



Metal	$\alpha\ \left(10^{-6}\ \mathrm{K}^{-1}\right)$
iron	11,8
nickel	13,0
copper	16,4
aluminium	24,0

a. Lamp A lights up.
b. Lamp B lights up.
c. Both lamps light up simultaneously.
d. No lamp is lit.

8. The half-life of a certain radioactive substance is determined in a physics laboratory. It is 4 days. After how many days has the activity of the sample been reduced to 12.5 % of the original activity?

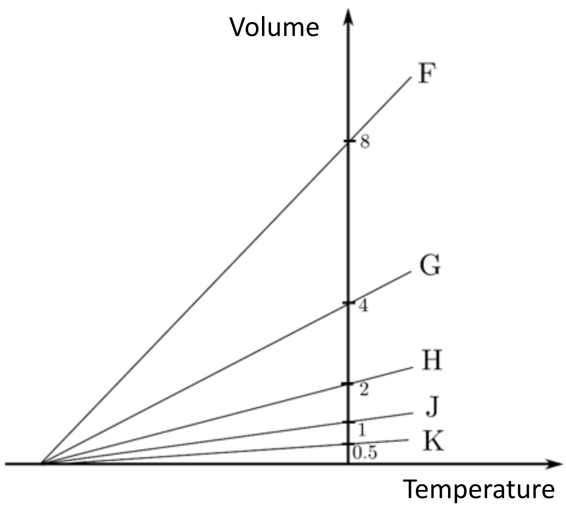
a. 4 days
b. 8 days
c. 12 days
d. 16 days

9. An electric heater with a resistance R is connected to a power source with a voltage V. In Europe, where this voltage is approximately 240 V, the heater has a certain power output P_1. The same heater is now plugged in in the United States, where the voltage is only 120 V. What is the power output P_2 now?
   a. $P_2 = P_1$
   b. $P_2 = P_1/2$
   c. $P_2 = P_1/4$
   d. None of the above

10. A rifle bullet with a mass of 40 g hits a stationary target with a velocity of $1000\ \mathrm{m/s}$ and gets stuck there. The target has a mass of 40 kg and can move freely. What is the approximate velocity v of the target immediately after being hit by the bullet?
    a. $v \approx 1\ \mathrm{m/s}$
    b. $v \approx 10\ \mathrm{m/s}$
    c. $v \approx 0.5\ \mathrm{m/s}$
    d. $v \approx 1000\ \mathrm{m/s}$

11. An elastic ball is released from a height of $80\ \mathrm{cm}$ and bounces a few times on the floor. At each bounce, the ball loses energy due to friction and retains only a percentage p of its energy. After 3 bounces, the height of the bounce has reduced to $10\ \mathrm{cm}$. What is the percentage p ?
    a. $p \approx 12.5\ \%$
    b. $p \approx 50\ \%$
    c. $p \approx 25\ \%$
    d. $p \approx 40\ \%$

12. An ideal gas of mass m undergoes expansion at constant pressure p. The straight line H in the graph shows this expansion. Which line represents the expansion of a mass $2m$ of the same gas, at constant pressure $p/2$?

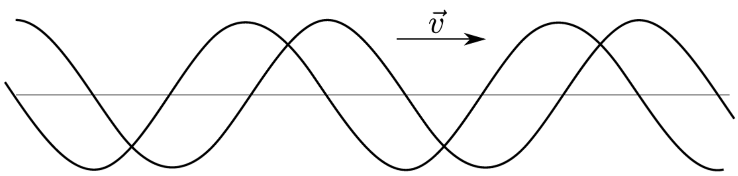


    a. Line F
    b. Line G
    c. Line H
    d. Line J
    e. Line K

13. A stone is thrown upwards. The stone reaches the maximum height h at the time t. How high was it at time $t/2$? (Air resistance can be neglected.)
    a. $h/4$
    b. $h/3$
    c. $h/2$
    d. $2h/3$
    e. $3h/4$

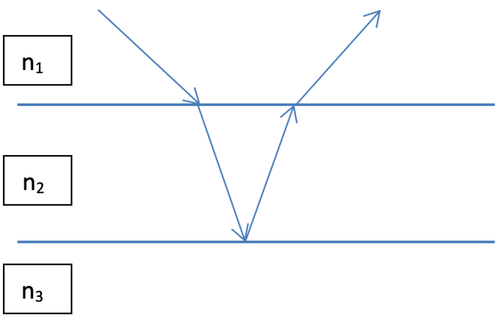
14. In a normal classroom, the number of air molecules is approximately:
    a. 10^9
    b. 10^{15}
    c. 10^{23}
    d. 10^{28}
    e. 10^{35}

15. The figure shows two waves of the same amplitude X and the same wavelength, propagating in the same direction. The first wave is a quarter of a wavelength ahead of the second. What can we say about the amplitude of the resulting wave?



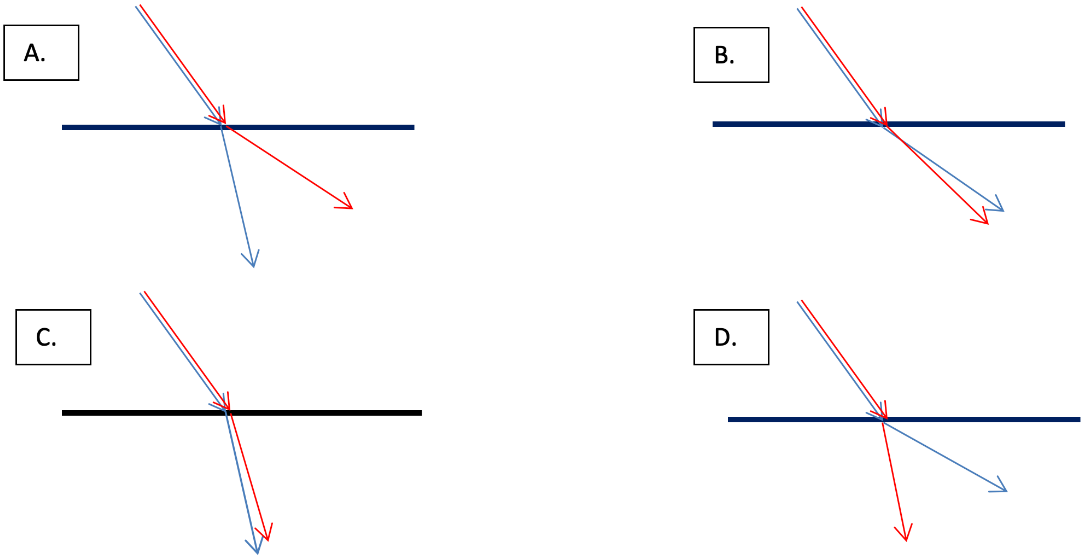
    a. It is 0
    b. It is $2X$
    c. It lies between 0 and X
    d. It lies between X and $2X$

16. A light ray hits a layer of transparent media with refractive indices n_1, n_2 and n_3. The (symmetrical) path of the light is shown below.



Which statement is correct for the refractive indices?
    a. $n_2 > n_1 > n_3$
    b. $n_1 > n_2 > n_3$
    c. $n_2 > n_3 > n_1$
    d. $n_3 > n_2 > n_1$

17. A sound wave and a light wave hit the boundary layer between air and water with the same angle of incidence. Which of the following diagrams corresponds to the subsequent refraction?



a. A
b. B
c. C
d. D

18. When running, a person converts approximately $0.600\ \mathrm{J}$ of chemical energy into mechanical energy per step and per kilogram of body mass. If a runner of $60\ \mathrm{kg}$ transforms his energy at a rate of $70.0\ \mathrm{W}$ during a run, at what speed (in $\mathrm{m/s}$) is he running? Let's assume that a running step is $1.50\ \mathrm{m}$ long.
a. 2.32
b. 2.92
c. 3.52
d. 4.12

19. A wooden cube with a side length of $20\ \mathrm{cm}$ and a density of $650\ \mathrm{kg/m^3}$ floats on the water. What is the distance (in cm) between the top horizontal surface of the cube and the water level?
a. 1
b. 3
c. 5
d. 7

20. A 2.0 kg piece of wood slides over the surface shown in the figure below. The curved sides are perfectly smooth, but the rough horizontal surface is 30 m long and has a kinetic friction coefficient of 0.20 with the wood. The piece of wood starts at rest from a height of 4.0 m above the rough surface. Where will this wooden piece end up?

a. 15 m
b. 20 m
c. 25 m
d. 28 m (after turning back)