

Qualification



Unless otherwise specified:

Correct answer: 5 points

No answer: 1 point

Incorrect answer: 0 point

Use:

$$g = 10 \text{ m/s}^2$$

$$\text{Volume of a sphere: } \frac{4}{3}\pi r^3$$

$$\text{Surface area of a sphere: } 4\pi r^2$$

$$\text{Area of a disc: } \pi r^2$$

Radius of the Earth: 6400 km

Density of water: 1000 kg/m³

Standard atmospheric pressure: 101,3 kPa

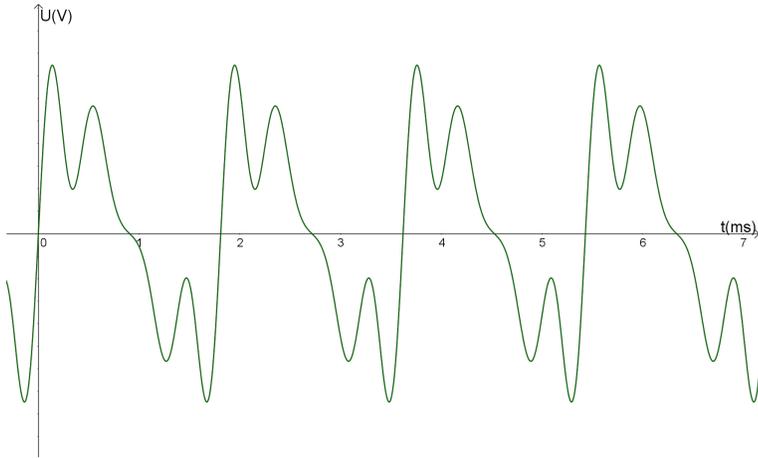
Avogadro's Number: $6,02 \cdot 10^{23} \text{ mol}^{-1}$

Elementary electric charge: $1,60 \cdot 10^{-19} \text{ C}$

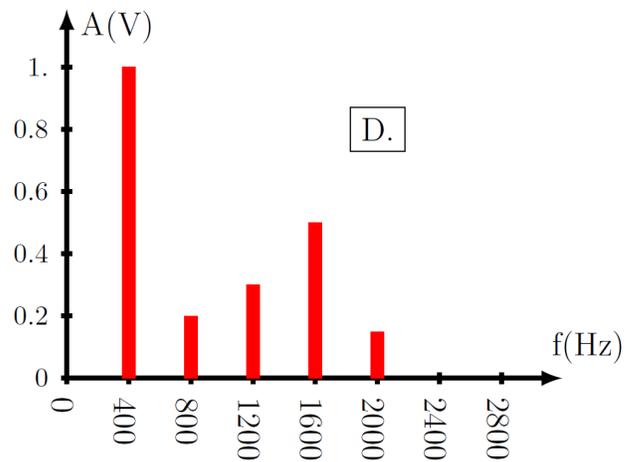
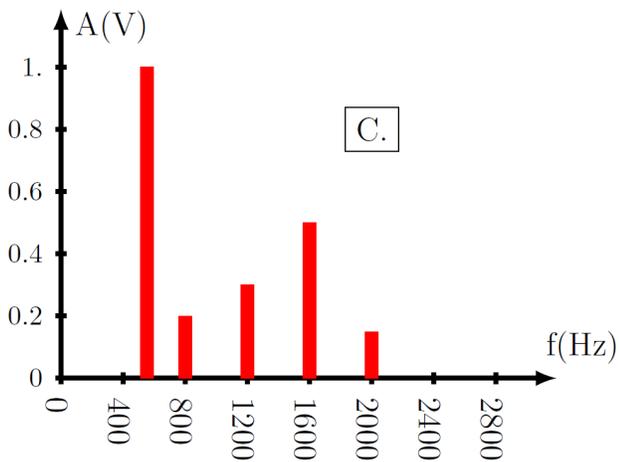
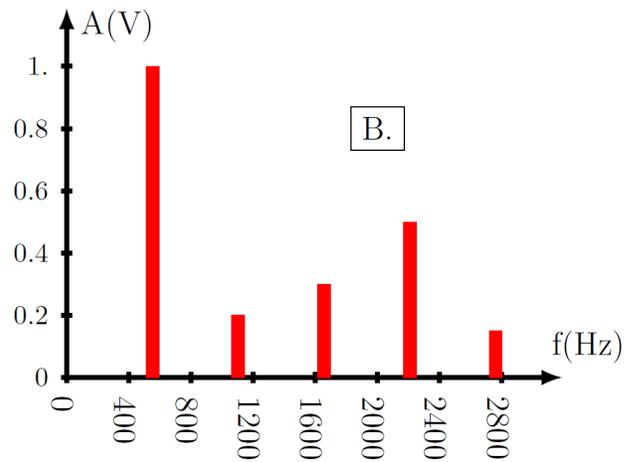
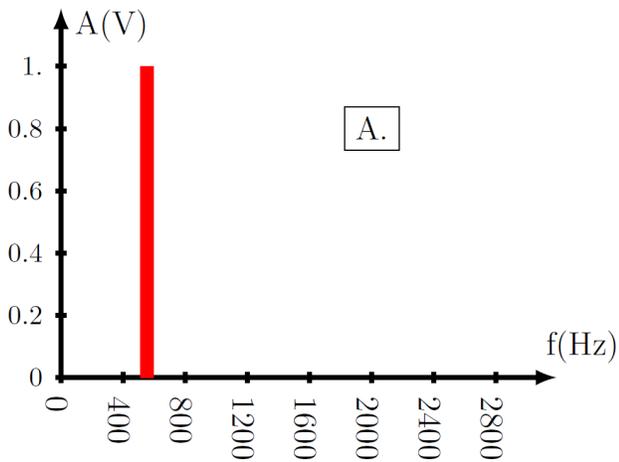
Mass of the electron: $9,11 \cdot 10^{-31} \text{ kg}$

1

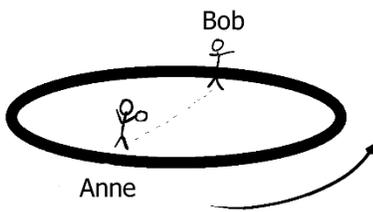
A pianist hits a string by pushing the C key. The string undergoes free oscillations. A microphone is used to record the corresponding sound. An oscilloscope displays the recorded sound which looks as follows:



Which of the following spectra corresponds to the pitch of the emitted sound?



2



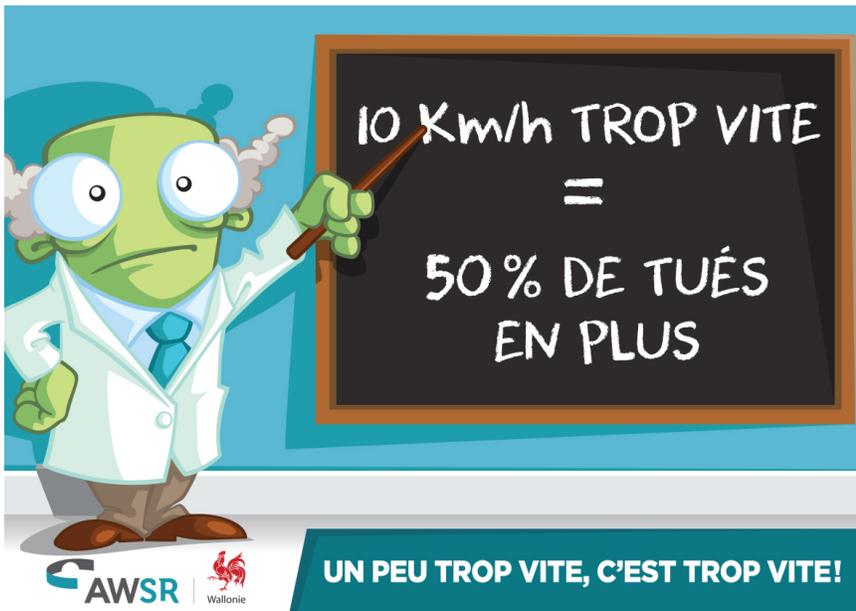
Anne and Bob are standing on opposite points of a merry-go-round. The latter has a radius of 4 m and rotates with a rotational speed of 5 turns/min. Anne throws a ball with an initial speed of 10 m/s in her reference frame in Bob's direction.

What is the initial speed of the ball in Bob's reference frame?

- (A) 2,1 m/s (B) 7,9 m/s (C) 10 m/s (D) 10,8 m/s (E) 12,1 m/s
-

3

A sign of the 'Sécurité routière' warns: "Speeding by 10 km/h = 50% more deaths". The mortality rate is assumed to be proportional to the kinetic energy of the vehicle.



Which of the following correctly indicates the speed for which this is true?

- (A) 100 km/h (B) 110 km/h (C) 44,5 km/h (D) 140 km/h (E) 90 km/h
-

4

On a clear summer night young Albert observes the stars. Suddenly a long yellow streak crosses the sky. It is visible for about one second: a meteorite! Albert estimates that the trace subtends an angle of 10° . Knowing that meteorites typically burn up because of air friction at an altitude of around 100 km, which of the following is the best estimate for the speed of the object with respect to the ground?

- (A) 17,5 km/s (B) 1,13 km/s (C) 30 km/s (D) 2,78 km/s
-

5

Supermarkets sell cubes made of rock which can be placed in the freezer at -20°C . When they are cooled down they can be used to cool drinks in summer. The ice cubes all have the same size and they are made from the following materials.

Material	ice	sandstone	marble	granite	limestone
density (kg/m^3)	917	1600	2700	2500	2000
specific heat capacity ($\text{J}/(\text{kg}\cdot\text{K})$)	4200	920	880	790	920
specific heat of fusion (kJ/kg)	333 at 0°C	X	X	X	X

Which material has the highest cooling potential?

- (A) Ice (B) Sandstone (C) Marble (D) Granite (E) Limestone
-

6

Heard on the radio: “When I use the speakers of my mobile phone, they produce energy, don’t they? If I can collect this energy using an adequate receiver, I can recharge my phone. Easy!”

Therefore:

I Yes, I won’t have to charge my phone!

II Yes, it’s a good idea, but I would have to use the speakers at high volume in order to charge the phone.

III No, it’s better not to use the speakers. Otherwise I have to recharge my phone more often.

IV No, because the efficiency of energy transformations is limited.

Which of the above statements is/are acceptable?

- (A) I (B) II and III (C) IV (D) III and IV (E) II and IV
-

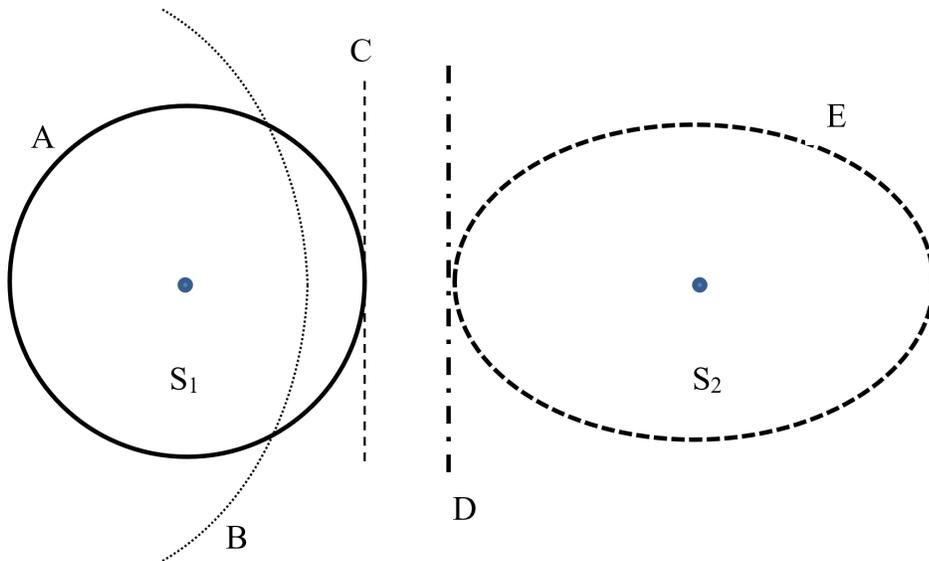
7

A marble is released in a vacuum from a height h above the ground. It recoils from the ground without losing energy. What is the period T of this system?

- (A) $T = 2\sqrt{\frac{2h}{g}}$ (B) $T = 2\pi\sqrt{\frac{h}{g}}$ (C) $T = 2\sqrt{\frac{g}{2h}}$
(D) $T = 2\pi\sqrt{\frac{g}{h}}$ (E) $T = \sqrt{\frac{2h}{g}}$
-

8

The same sound is perceived at 2 different points S_1 and S_2 at two different instants $T_1 = 14\text{h } 2\text{ min } 5\text{ s}$ and $T_2 = 14\text{h } 2\text{ min } 6,5\text{ s}$. The speed of sound is equal to 340 m/s . Which of the following curves represents the locus of points from which the sound could originate?



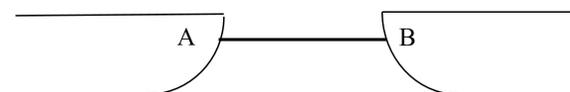
9

A block of pure silicon has a resistivity of $2300\ \Omega \cdot m$. The block has a size of $7\text{cm} \times 8\text{cm} \times 0,019\text{cm}$. What is the value of the maximum electrical resistance between 2 opposite sides?

- (A) $5.393\ \text{M}\Omega$ (B) $7.383\ \text{M}\Omega$ (C) $10.11\ \text{M}\Omega$ (D) $13.83\ \text{M}\Omega$ (E) $6.310\ \text{M}\Omega$
 (F) $8.638\ \text{M}\Omega$ (G) $11.82\ \text{M}\Omega$ (H) $16.19\ \text{M}\Omega$

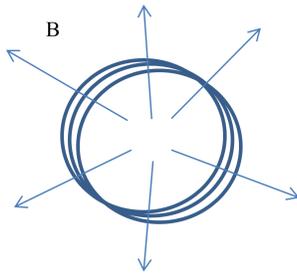
10

A rope is stretched between 2 boats A and B. Boat A has a mass of 3 tons and boat B has a mass of 2 tons. A person whose mass is 60kg sits her/himself in the middle of the rope. Both halves of the rope are now at an angle of 60° to the horizontal direction. What is the horizontal acceleration of the boats at this moment?



- (A) $a_A = \frac{1}{10\sqrt{3}}$ and $a_B = \frac{15}{100\sqrt{3}}$ (B) $a_A = a_B = \frac{1}{10}$ (C) $a_A = \frac{1}{10}$ and $a_B = \frac{3}{20}$
 (D) $a_A = \frac{\sqrt{3}}{60}$ and $a_B = \frac{\sqrt{3}}{40}$

11



Vue aérienne

A conducting coil is suspended in a horizontal plane in a region of constant radial magnetic field of value B . R is the radius of the coil windings, m the mass of the coil and I the current passing through the wire. Which of the following gives the correct direction and value of the magnetic force on the coil?

- (A) The force is vertical and the magnitude is $F = 2\pi R B I$
- (B) The force is radial and its magnitude is $F = 2\pi R B I$
- (C) The force is vertical and the magnitude is $F = \pi R^2 B$
- (D) There is no resulting force
- (E) The force is radial and the magnitude is $F = \frac{B I}{2\pi R}$

12

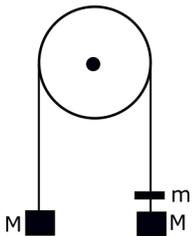
The angular amplitude of a pendulum is 0,15 rad and the speed on the lowest point is 0,68 m/s. What is the oscillation period?

- (A) 0,32 s
- (B) 1,25 s
- (C) 2,85 s
- (D) 6,21 s
- (E) 10 s

13

An Atwood machine is in equilibrium when two equal masses M are hanging on the two sides of the pulley. When an additional mass m is added on one side as shown below, the system accelerates uniformly. What is the acceleration of the system?

- (A) $a = \frac{g \cdot m}{m + M}$
- (B) $a = \frac{g \cdot m}{2 \cdot M}$
- (C) $a = \frac{g \cdot m}{m + 2M}$
- (D) $a = \frac{g \cdot (m + M)}{m + M}$



14

What is the ratio of the masses of the sun M_S and the earth M_T knowing that the period of revolution of the Earth around the sun is $T_1 = 365,25$ days and that of the Moon around the Earth is $T_2 = 27,32$ days. Consider that the mean radius of the trajectory of the Earth around the Sun is $R_1 = 149 \cdot 10^6 \text{ km}$ and mean radius of the trajectory of the Moon around the Earth is $R_2 = 384,4 \cdot 10^3 \text{ km}$.

- (A) $\frac{M_S}{M_T} = 1,1 \cdot 10^5$ (B) $\frac{M_S}{M_T} = 2,2 \cdot 10^5$ (C) $\frac{M_S}{M_T} = 3,3 \cdot 10^5$ (D) $\frac{M_S}{M_T} = 4,4 \cdot 10^5$
-

15

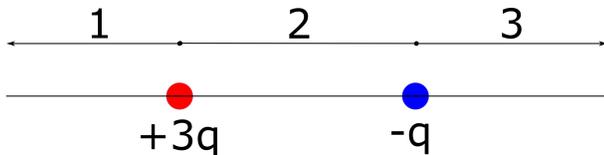
A cylindrical container has a capacity of 4 litres and a mass of 245g. It can be closed using a flat lid with a diameter of 16 cm. It can be assumed that the lid acts like an airtight seal. The open container is first placed in a room where the temperature is 20°C . It is then closed using the lid and moved to very cold room. The air pressure in both rooms is equal to 1000 hPa. What does the temperature of the air in the container have to be in order to be able to lift the container up by its lid?

- (A) $19,6^\circ\text{C}$ (B) $18,5^\circ\text{C}$ (C) $17,2^\circ\text{C}$ (D) $16,4^\circ\text{C}$ (E) $15,3^\circ\text{C}$
-

16

2 point charges of charge $+3q$ and $-q$ are placed on an axis named Ox in an otherwise empty space.

In which of the regions along Ox can the electric field be zero (apart from infinity)?



- (A) Region 2 only (B) Region 3 only (C) Regions 1 and 2
(D) Regions 1 and 3 (E) Regions 2 and 3
-

17

S waves (transversal) and P waves (longitudinal) generated during an earthquake travel at different speeds. S waves propagate at a speed of 4000 m/s and P waves at 7000 m/s. At what distance from the epicentre of the earthquake does an observer have to be in order for the P waves to arrive 2 minutes before the S waves.

- (A) 360 km (B) 480 km (C) 840 km (D) 1120 km (E) 1320 km
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