PHYSIKSOLYMPIAD
LËTZEBUERG 2018

Qualification(EN)

4.1.2018

Formulas

Kinematics (UAM)

$x = \frac{1}{2}at^2 + v_0t + x_0$

$v = at + v_0$

$v^2 - v_0^2 = 2a(x - x_0)$

Forces

$F = ma$

$F_f \leq \mu N$

Work, Energy, Power

$W = Fd\cos\theta$

$E_{cin} = \frac{1}{2}mv^2$

$E_{pes} = mgh$

$E_{el} = \frac{1}{2}kx^2$

$P = \frac{W}{t} = Fv$

Momentum

$p = mv$

$F = \frac{\Delta p}{\Delta t}$

Thermal concepts

$Q = mc\Delta\theta$

$Q = mL$

Ideal gas

$p = \frac{F}{A}$

$pV = nRT = Nk_BT$

$E_K = \frac{3}{2}k_BT$

Oscillations and waves

$T = \frac{1}{f}$

$c = f\lambda$

$T = 2\pi\sqrt{\frac{l}{g}}$

$T = 2\pi\sqrt{\frac{m}{k}}$

Electricty

$I = \frac{Q}{t}$

$F = k \cdot \frac{q_1q_2}{r_2}$

$V = \frac{W}{q}$

$E = \frac{F}{q}$

$V = RI$

$P = VI = RI^2 = \frac{V^2}{R}$

$R = R_1 + R_2 + \cdots + R_n$

$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}$

$\rho = \frac{RA}{L}$

Electro-magnetism

$F = qvB\sin\theta$

$F = BIL\sin\theta$

Circular motion

$v = \omega r$

$a = \frac{v^2}{r}$

Gravitation

$F = G\frac{mM}{r^2}$

$g = \frac{F}{m}$

Quantum physics

$E = hf$

$\lambda = \frac{hc}{E}$

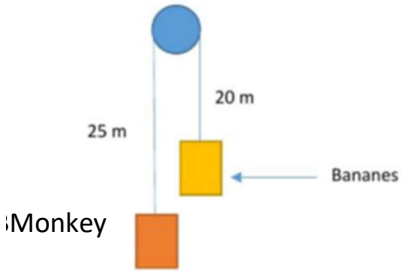
Optics

$n_1\sin\alpha_1 = n_2\sin\alpha_2$

$\frac{1}{q} + \frac{1}{p} = \frac{1}{f}$

Question 1

A case of bananas of mass m hangs 20 m from a pulley. On the other side, a monkey with mass m is 25 m from this pulley. Knowing that he has enough energy to lift his weight 20 m along the rope, will he reach the bananas to eat them? Neglect the mass of the pulley and its friction.



a) No, bananas will rise to the top and the monkey will remain on the spot.

b) Yes, the monkey will go up and the bananas will remain on the spot.

c) No, the monkey and the bananas will go up without the monkey being able to catch them.

d) Yes, the monkey and the bananas will go up, but the monkey will catch the bananas.

Question 2

Assuming that you can fold a sheet of paper (thickness of the order of 10th of a mm) in half without being limited to 7 or 8 times, how many times should this sheet be folded to reach the Moon, located at 384 400 km?

a) 42

b) 71

c) 168

d) 253

Question 3

A person looks in a mirror. She sees that the top of her head exactly coincides with the top of the mirror. The same for her feet that exactly coincide with the bottom of the mirror. If this same person goes forward to look at herself more closely, what will happen?

a) She will cover the entire mirror, with her head and feet at the ends.

b) She will cover the entire mirror but will no longer see her feet or her head.

c) She will no longer cover the entire mirror and will be able to see a piece of the sky above her head, and the ground under her feet.

d) She will see her feet in the bottom of the mirror but not all of her head.

Question 4

You make a journey by car and want to make the same trip twice. During the first trip, you drive with an average speed of 50 km / h. At what average speed should you travel the second time so that your average total speed is 60 km / h?

a) 70 km / h

b) 75 km / h

c) 80 km / h

d) 90 km / h

Question 5

The date is March 21 at the equator. On this equinox day, the sun rises at 6 o'clock, is at its peak at 12 o'clock, and then sets at 6 pm. We plant a stick vertically. At 2 pm, we observe that the shadow of this staff measures L. What will be the length of this same shadow at 4 pm?

a) 0.5L

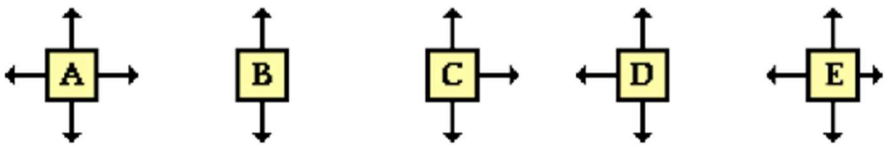
b) 2L

c) 3L

d) 5L

Question 6

The diagrams below show the direction and intensity of the forces applied to the bodies A, B, C, D and E. Which of the bodies could be moving to the right?



a) Only the bodies A, D and E

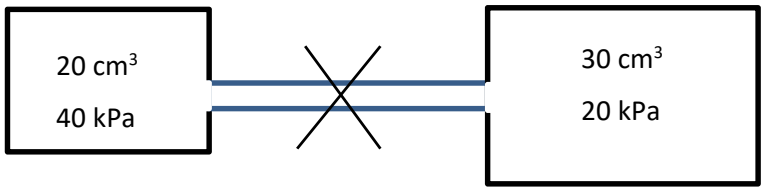
b) Only the bodies D and E

c) Only the bodies A, B, D and E

d) All

Question 7

Two tanks A and B of volume 20 cm3 and 30 cm3 are filled with air at the same temperature and connected by a pipe initially closed by a valve. The pressure in A is 40 kPa and the pressure in B is 20 kPa.



The valve is opened slowly so that the temperature does not change. What is the final pressure in the tanks?

a) 28 kPa

b) 30 kPa

c) 32 kPa

d) 60 kPa

Question 8

What is the altitude h, above the earth's surface, at which the intensity of the gravitational force exerted by the Earth on an object, is worth half of its value on the ground? (The radius of the Earth is 6,370 km)

a) 2,638 km

b) 185 km

c) 6,370 km

d) 2,740 km

Question 9

You call a professional tuner to have your new grand piano tuned. The tuner hits a tuning fork and a piano key of the same note and listens to the beats. How long will it theoretically take you to tune your instrument to perfection?

a) Duration equal to the inverse of the difference of the tuning fork and piano frequencies

b) Duration equal to 10 times the inverse of the difference of the tuning fork and piano frequencies

c) Duration equal to 1000 times the inverse of the difference of the tuning fork and piano frequencies

d) Infinite duration

Question 10

A Battery has an emf of 10 V and an internal resistance of 5.0 Ω. It is connected to an external resistance resistor R. What is the intensity of the electric current in the circuit when a maximum power is output in R?

a) 2.0 A

b) 1.8 A

c) 1.2 A

d) 1.0 A

Question 11

Two flat mirrors form an angle of 60 ° between their reflecting surfaces. We put a candle between the two mirrors. How many candles (images and object) can we observe?

a) 2

b) 5

c) 6

d) 12

Question 12

An air bubble is created under water. A light beam composed of parallel rays falls on the bubble. Which of the following is correct?

a) The rays will pass through the bubble and converge.

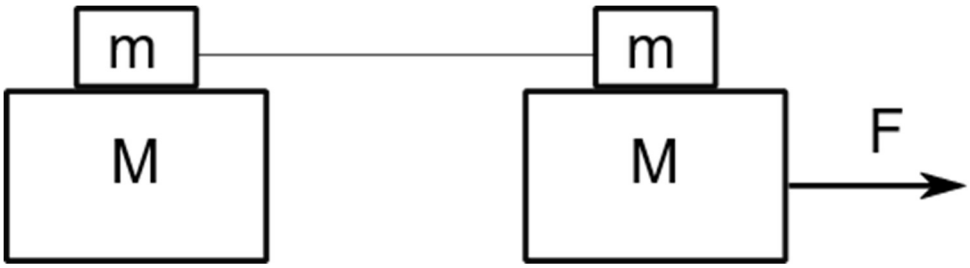
b) The rays will all be reflected by total reflection.

c) The rays will pass through the bubble and diverge.

d) The rays will not be deflected.

Question 13

There are 4 masses arranged as shown in the diagram below and connected by a cord of negligible mass. We neglect the friction with the ground and we consider a coefficient of static friction μ between the masses. What is the maximum force F that can be applied without causing a slippage between the masses?



a) $F = \frac{m \cdot g \cdot \mu}{M}$

b) $\mathrm{F} = \frac{\mathrm{m \cdot g \cdot \mu \cdot (2m+2M)}}{\mathrm{2m+M}}$

c) $\mathrm{F} = \frac{\mathrm{m \cdot M \cdot g \cdot \mu}}{\mathrm{2m+2M}}$

d) $\mathrm{F} = \frac{\mathrm{m \cdot g \cdot \mu \cdot (m+M)}}{\mathrm{2m+M}}$

Question 14

A pendulum is composed of a point mass m placed at the end of a thread of negligible mass and length l. This pendulum is placed in a horizontal centrifuge of radius $R \gg \ell$ which rotates with a rotation speed ω. What is the period of the pendulum according to other variables?

a) $T = 2\pi\sqrt{\frac{\ell}{g}}$

b) $T = 2\pi\sqrt{\frac{m}{g}}$

c) $T = 2\pi\sqrt{\frac{\ell}{\sqrt{g^2+\omega^4 R^2}}}$

d) $T = 2\pi\sqrt{\frac{R}{g+\omega^2 R}}$

Question 15

Venus has a diameter of 12.1 10^3 km and an average density of 5.2 10^3 kg/m³. How far would a body fall in one second near its surface? (The universal constant of gravitation is: G = 6,67·10^{-11} SI units)

a) 4.4 m

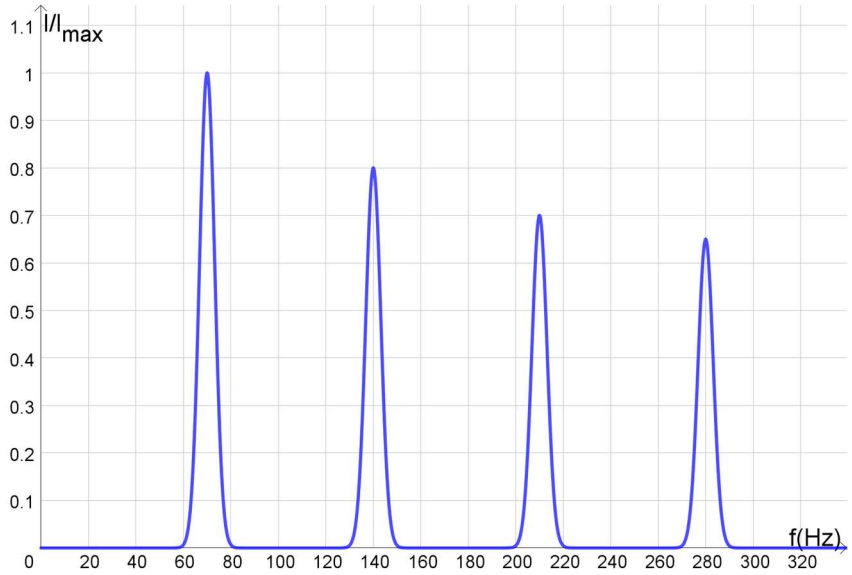
b) 1.5 m

c) 2.7 m

d) 7 m

Question 16

Considering the spectrum of an acoustic signal below, identify the erroneous statement.



a) The fundamental frequency is approximately 70 Hz
b) It could be a sound emitted by an open-open tube.
c) It could be a sound emitted by an open-closed tube.
d) It could be the sound emitted by a closed-closed tube.

Question 17

One end of a blade is fixed and the other end vibrates with a sinusoidal movement of frequency 50 Hz and amplitude 0.5 cm. Determine its acceleration when the elongation is maximum.

a) 7.3 m / s^2

b) 31 m / s^2

c) 4.9 · 10^2 m / s^2

d) 2.2 · 10^3 m / s^2

Question 18

What is the wavelength in the vacuum of an electromagnetic wave of 20 Hz? (The speed of the light is $3 \cdot 10^8$ m / s.)

a) $1.5 \cdot 10^7$ m

b) $1.5 \cdot 10^5$ m

c) $1.5 \cdot 10^{10}$ m

d) $4.7 \cdot 10^5$ m

Question 19

A 70 kg person, in moderate physical activity, produces thermal energy at a rate of 200 kcal / h. If the body's cooling mechanisms no longer work, i.e. it can no longer get rid of that energy. How long does it take for this person to faint, having reached a body temperature of 43 ° C?

The average specific heat of the human body is 3.5 kJ / (kg · K); 1 cal = 4.184 J.

a) 1.8 h

b) 45 min

c) 17 min

d) 5 min

Question 20

Determine the mass of helium needed to provide enough thrust (in dry air at 0 ° C) to lift a balloon and its load, total mass 454 kg.

Density of air at 0 ° C: $\rho = 1.29$ kg / m³; Density of helium: $\rho = 0.178$ kg / m³.

a) 72.7 kg

b) 150.3 kg

c) 90.1 kg

d) 251.8 kg