Test in Physics

Every correctly circled reply with detailed procedure and adequate explanation is marked with 5 points. For incorrectly circled reply procedure is not considered.

1. A wagon moving at constant speed v_1=2 m/s has a narrow tube placed at angle α=60° to the horizontal direction (Figure 1). What is the speed v_2 of the raindrop, falling at constant speed, if it falls at the point A without touching the walls of the tube?

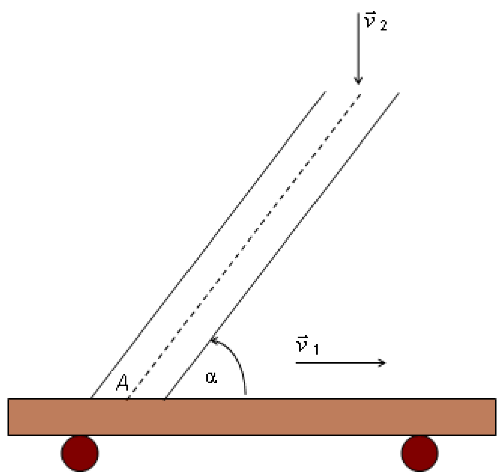

Figure 1

a) v_2=1.15 m/s b) v_2=4 m/s c) v_2=1 m/s
d) v_2=3.46 m/s e) v_2=2.5 m/s

2. A tenis ball is served from a hight H=2.5 m, with a speed v=108 km/h. If a player taking the service is located at distance l=12 m from a net which is h=0.9 m high, and the area, behind the net, alowed for the ball to fall is s=8 m long (in the direction in which the ball is traveling), what is the range of angles for which the player performs the correct service?

a) $\alpha \in (-3.87°, -0.91°)$ b) $\alpha \in (-7.25°, 0.12°)$ c) $\alpha \in (0°, 2°)$
d) $\alpha \in (-1.7°, 0°)$ e) $\alpha \in (-7.25°, -4.12°)$

3. Two equal boats, each with mass m=180 kg, are moving in the parallel directions. The boats sale one to another at the same speed v_0=3 m/s, relative to the lake shore. Each boat carries a package whose mass is m_1=20 kg. When the boats are passing by each other, the package is transferred from the first boat to the second and immediately after identical package is transferred from the second boat to the

first one. If the friction between boats and water is negligible, what are their speeds after they pass each other?

a) v_1=2 m/s; v_2=4 m/s
b) v_1=-v_2=2.45 m/s
c) v_1=3.33 m/s; v_2=2.7 m/s
d) v_1=-v_2=2.4 m/s
e) v_1=3.85 m/s; v_2=1.35 m/s

4. Figure 2 shows a system of two serially connected elastic springs, whose stiffness coefficients are k_1 and k_2. What is the minimum mechanical work needed to starch the system for Δx?

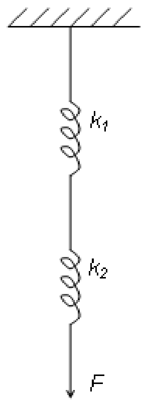

Figure 2

a) $A_{\min} = \frac{1}{2}(k_1 + k_2)(\Delta x)^2$
b) $A_{\min} = \frac{1}{2}k_2(\Delta x)^2$
c) $A_{\min} = \frac{1}{4}(k_1 + k_2)(\Delta x)^2$
d) $A_{\min} = \frac{k_1 k_2}{k_1 + k_2}(\Delta x)^2$
e) $A_{\min} = \frac{k_1 k_2}{2(k_1 + k_2)}(\Delta x)^2$

5. Two rigid rulers are placed parallel to each other at distance d=2 cm, at angle α=5˚ to the horizontal direction (Figure 3). A ball with radius r=1.5 cm is rolling down the rulers. What is the acceleration of the ball if it doesn't slide?

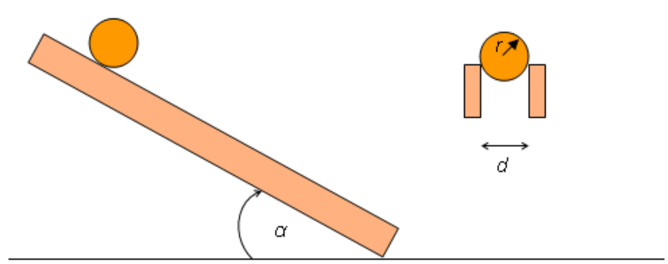

Figure3

a) a_{cm}=0.85 m/s^2
b) a_{cm}=34.3 cm/s^2
c) a_{cm}=49.7 cm/s^2
d) a_{cm}=0.427 m/s^2
e) a_{cm}=29.82 cm/s^2

6. A missile is launched from the Earth's surface to the Moon in the direction connecting the centers of mass of these two celestial bodies. The mass of the Earth is M_E, and its radius is R_E=6370 km. The mass of the Moon is $M_M=M_E/81$ and the gravitational acceleration at its surface is $g_M=g/6$ (g is the acceleration at the Earth's surface). The distance between centers of the Earth and the Moon is $D=60\cdot R_E$. What is the minimum speed v_o at which the missile should be launched to reach the Moon? The motion of the Earth and the Moon can be ignored as well as the friction between the missile and the medium trough which it travels.

a) v_0=11.2 km/s
b) v_0=11.08 km/s
c) v_0=4.3 km/s
d) v_0=5.54 km/s
e) v_0=1.11 km/s

7. A homogenous heavy rod of length l can slide along the inner side of a smooth cylindrical container with radius R ($R>l/2$). What is the small oscillation angular frequency of the rod around the equilibrium position (Figure 4)?

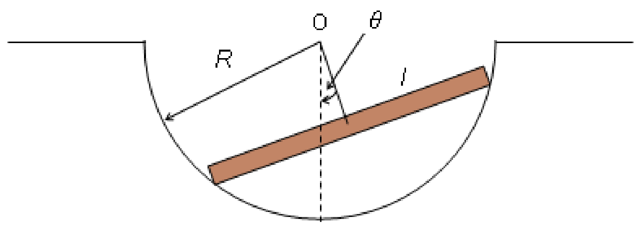

Figure 4

a) $\omega_0 = \sqrt{\dfrac{3g\sqrt{4-(l/R)^2}}{R\left(6-(l/R)^2\right)}}$
b) $\omega_0 = \sqrt{\dfrac{6gl/R}{R\left(4-(l/R)^2\right)}}$
c) $\omega_0 = \sqrt{\dfrac{3g\sqrt{4-(l/R)^2}}{4R}}$
d) $\omega_0 = \sqrt{\dfrac{2g}{R\left(12-(l/R)^2\right)}}$
e) $\omega_0 = \sqrt{\dfrac{4g\sqrt{3-(l/R)^2}}{6R\left(1-(l/R)^2\right)}}$

8. A metal rod of length l=2 m is trapped at two points separated by a distance $l/2$. The points are placed symmetrically with respect to the center of the rod. A speed of sound wave propagating through the rod is c=4100 m/s. What is the frequency of the second harmonic oscillation on the rod?

a) v=10450 Hz
b) v=5125 Hz
c) v=3075 Hz
d) v=10250 Hz
e) v=6150 Hz

9. A hemisphere of radius R is made of wood with density ρ, and it is submerged in a liquid with density ρ_0, as it is shown in Figure 5. What is the force $\vec{F}$ required to keep the flat surface of the hemisphere at the free surface of liquid?

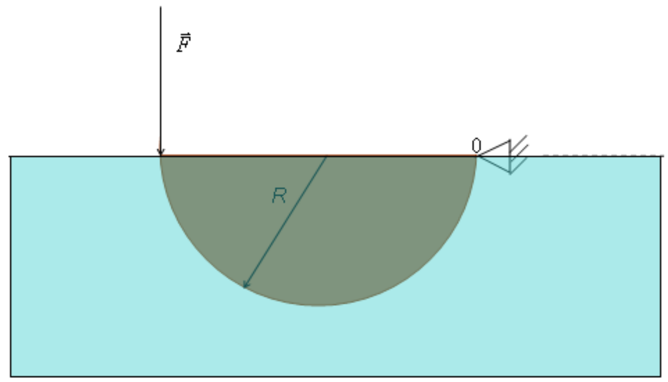

Figure 5

a) $F=\frac{2}{3}\pi gR^3(\rho_0-\rho)$ b) $F=\frac{1}{2}\pi gR^3(\rho_0+\rho)$ c) $F=\frac{4}{9}gR^3(\rho_0-\rho)$
d) $F=\frac{4}{9}gR^3(\rho_0+\rho)$ e) $F=\frac{1}{3}\pi gR^3(\rho_0-\rho)$

10. A small wooden ball spontaneously emerges towards free water surface at a constant speed v=0.75 m/s. The viscosity of water is η=0.8 MPas, and the wood density is ρ=800 kg/m^3.What is the radius of the ball?

a) r=0.27 cm b) r=9.17·10^{-2} cm c) r=0.12 cm
d) r=1.23 cm e) r=3 cm

11. What percentage of molecules in some gas has a speed that differs from the most probable speed by not more than 1 %?

a) 0.83 % b) 0.61 % c) 1.66 %
d) 0.31 % e) 2.1 %

12. A tank containing nitrogen at a temperature t_1=15 ˚C is moving with a speed v=100 m/s. What is the gas temperature t_2 in the tank when it is suddenly stopped? Ignore a transfer of heat to the walls of the tank? (c_{vN2}=714.29 J/kg˚C)

a) t_2=22 ˚C b) t_2=18,5 ˚C c) the gas temperature doesn't change
d) t_2=25 ˚C e) t_2=29 ˚C

13. Three clips share a gas in a closed horizontal cylinder into four parts. The gas state parameters in the each part are: p_1, V_1, T_1; p_2, V_2, T_1; p_3, V_3, T_1; p_4, V_4, T_1. Suddenly, the clips begin to move freely without friction until the steady state is reached. If the temperature in the cylinder is T_2 what is the pressure in each part of the cylinder?

a) $p = \dfrac{p_1V_1 + p_2V_2 + p_3V_3 + p_4V_4}{V_1 + V_2 + V_3 + V_4}$

b) $p = \dfrac{p_1V_1 + p_2V_2 + p_3V_3 + p_4V_4}{V_1 + V_2 + V_3 + V_4} \cdot \dfrac{T_1}{T_2}$

c) $p = \dfrac{p_1V_1 + p_2V_2 + p_3V_3 + p_4V_4}{V_1 + V_2 + V_3 + V_4} \cdot \dfrac{T_2}{T_1}$

d) $p = \dfrac{p_1 + p_2 + p_3 + p_4}{4}$

e) $p = \dfrac{p_1 + p_2 + p_3 + p_4}{4} \cdot \dfrac{T_2}{T_1}$

14. A cube is composed of alternatively arranged plates of different thickness and thermal conductivity (Figure 6). What is the ratio of the longitudinal ($\lambda_{||}$) and transversal ($\lambda_{\perp}$) conductivity of the cube? The thermal conductivities of the used plates are λ_1 and λ_2, their thicknesses are b_1 and b_2, and the number of plate pairs in the cube is n.

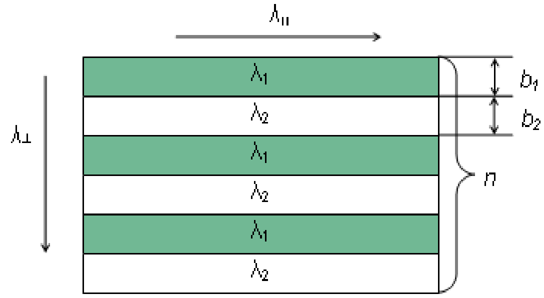

Figure 6

a) $\lambda_{||} / \lambda_{\perp} = \dfrac{n(\lambda_1 b_1 + \lambda_2 b_2)}{\left(\dfrac{b_1}{\lambda_1} + \dfrac{b_2}{\lambda_2}\right)(\lambda_1 + \lambda_2)^2}$

b) $\lambda_{||} / \lambda_{\perp} = \dfrac{(\lambda_1 + \lambda_2)(\lambda_1 b_1^2 + \lambda_2 b_2^2)}{n^2 \lambda_1 \lambda_2 (b_1 + b_2)^2}$

c) $\lambda_{||} / \lambda_{\perp} = \dfrac{n(\lambda_1 b_2 + \lambda_2 b_1)\left(\dfrac{b_1}{\lambda_1} + \dfrac{b_2}{\lambda_2}\right)}{(b_1 + b_2)^2}$

d) $\lambda_{||} / \lambda_{\perp} = \dfrac{(\lambda_1 b_1 + \lambda_2 b_2)\left(\dfrac{b_1}{\lambda_1} + \dfrac{b_2}{\lambda_2}\right)}{(b_1 + b_2)^2}$

e) $\lambda_{||} / \lambda_{\perp} = \dfrac{(\lambda_1 + \lambda_2)(\lambda_1 b_1^2 + \lambda_2 b_2^2)}{\lambda_1 \lambda_2 (b_1 + b_2)^2}$

15. A distance between the film and the screen in a cinema hall is d=40 m. How far from a lens of focal length f=0.2 m should the film be placed, in order to obtain a clear image on the screen? If the image size on the film strip is 24x35 mm^2 what is the image size on the screen?

a) p=-0.2 m
S=4.82×7.35 m^2

b) p=0.201 m
S=4.77×6.96 m^2

c) p=0.2 m
S=4.78×6.96 m^2

d) p=0.402 m
S=2.36×3,45 m^2

e) p=-0.4 m
S=2.42×3.53 m^2

16. Two parallel light rays 1 and 2 are traveling through the water (Figure 7). The ray 1 propagates directly into the air, while the ray 2 passes through the planparallel plate made of glass. Are the rays parallel to each other when they emerge into the air? What happens with the ray 2 if the ray 1 is totally reflected?

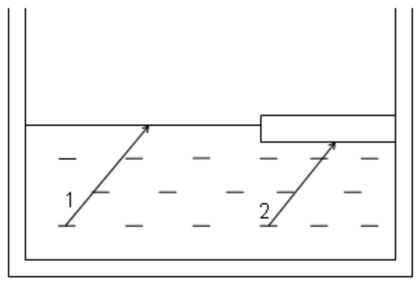

Figure 7

a) Yes. The ray 2 passes into the air.

b) Yes. The ray 2 is totally reflected from the top surface of the plate.

c) No. The ray 2 passes into the air.

d) Yes. The ray 2 is totally reflected from the bottom surface of the plate.

e) No. The ray 2 is totally reflected from the top surface of the plate.

17. Two equal plano convex lenses, made of glass with the refractive index n=1.6, are in touch by their spherical surfaces (Figure 8). What is the optical power of the lens system, if the radius of the fourth dark Newton's ring, in the refracted light of wavelength λ=600 nm, is r_4=1.5 mm?

Figure 8

a) ω=1.12 D
b) ω=0.56 D
c) ω=0.4 D
d) ω=0.93 D
e) ω=1.87 D

18. Do the first and second order white light (370 nm-780 nm) spectra overlap, when they are obtained by a diffraction grating? If they do, which part of the first order spectra is overlapped?

a) No.

b) Yes. Only the spectral line λ=780 nm is overlapped.

c) Yes. The wavelengths $\lambda \in$ (740 nm, 780 nm) are overlapped.

d) It depends on the diffraction grating constant.

e) Yes. The wavelengths $\lambda \in$ (370 nm, 390 nm) are overlapped.

19. What is the relative error with which the velocity of an electron on the first Bohr's orbit in a hydrogen atom is determined? The uncertainty of the electron coordinate is considered to be equal to the orbit diameter.

a) $\frac{\Delta v}{v} = 5\,\%$

b) $\frac{\Delta v}{v} = 11.3\,\%$

c) $\frac{\Delta v}{v} = 31.8\,\%$

d) $\frac{\Delta v}{v} = 25\,\%$

e) $\frac{\Delta v}{v} = 50\,\%$

20. What is De Broglie wavelength of the relativistic particle, with a rest mass m_0 and a charge q, if it is accelerated in the potential difference U?

a) $\lambda = \frac{h}{\sqrt{2m_0qU\left(1+\frac{qU}{2m_0c^2}\right)}}$

b) $\lambda = \frac{h}{\sqrt{2m_0qU}}\left(1+\frac{qU}{2m_0c^2}\right)$

c) $\lambda = h\frac{c}{qU}$

d) $\lambda = \frac{h}{\sqrt{2m_0qU}}$

e) $\lambda = \frac{h}{2m_0qU\left(1+\frac{qU}{2m_0c^2}\right)}$