Test in Physics

1. A mobile is formed by supporting four metal butterflies of equal mass *m* from a string of length *L*. The points of support are evenly spaced a distance *l* apart as shown in Figure t-1. The string forms an angle Θ_1 with the ceiling at each end point. The distance *D* between the end points of the string is:

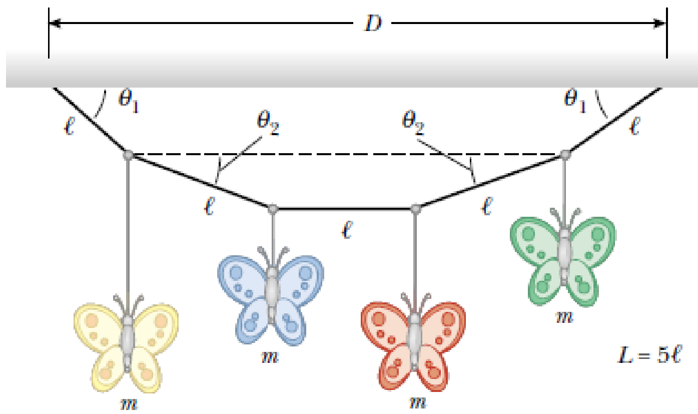

Figure t-1

a) $D = \frac{L}{5}\left\{2\cos\theta_1 + 2\cos\left(arcctg\left(\frac{1}{2}tg(\theta_1)\right)\right) + 1\right\}$

b) $D = \frac{L}{5}\{2\cos\theta_1 + 2\cos(arctg(tg(2\theta_1))) + 1\}$

c) $D = \frac{L}{5}\left\{2\cos\theta_1 + 2\cos\left(arctg\left(\frac{1}{2}ctg(\theta_1)\right)\right) + 1\right\}$

d) $D = \frac{L}{5}\{2\cos\theta_1 + 2\cos(arctg(2tg(\theta_1))) + 1\}$

e) $D = \frac{L}{5}\left\{2\cos\theta_1 + 2\cos\left(arctg\left(\frac{1}{2}tg(\theta_1)\right)\right) + 1\right\}$

2. A wearhouse with a width *a*=5m and a hight *h*=*a*/2 is located on a flat horizontal soil (Figure t-2). The roof height is small compared to the width of the building. The minimum velocity v_0 in which an object should be thrown from the ground so that it flies over the warehouse, and the relevant angle α are (g=10m/s^2):

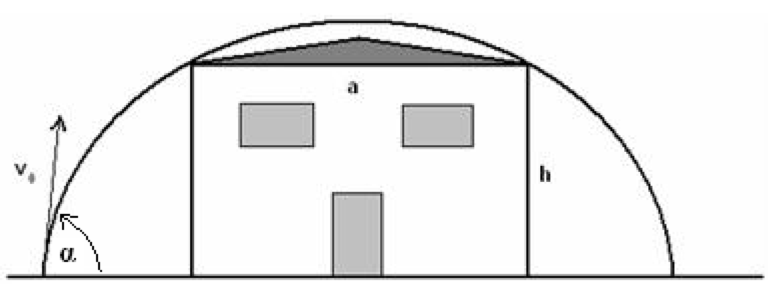

Figure t-2

a) $v_{0\min} = 10m/s, \alpha = 60^\circ$ b) $v_{0\min} = 11m/s, \alpha = 45^\circ$ c) $v_{0\min} = 15m/s, \alpha = 30^\circ$
d) $v_{0\min} = 9m/s, \alpha = 57^\circ$ e) $v_{0\min} = 12m/s, \alpha = 75^\circ$

3. A m_1=2kg aluminum block and a m_2=6kg copper block are connected by a light string over a frictionless pulley. They sit on a steel surface, as shown in Figure t-3, and θ=30°. The static and dynamic friction coefficients are μ_{Als}=0.61, µAld =0.47 for aluminum on steel, and μ_{Cus} =0.53, μ_{Cud} =0.36 for copper on steel, respectively. Do they start to move once any holding mechanism is released? What is the tension in the string?

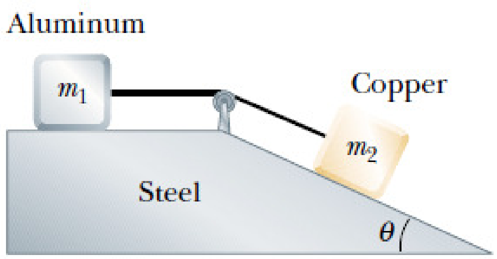

Figure t-3

a) yes, $S = 10N$ b) yes, $S = 12N$ c) no, $S = 12N$
d) no, $S = 2.5N$ e) no, $S = 27N$

4. A puck with a mass of 80g and a radius of 4cm slides along an air table at a velocity of 1.5m/s, as shown in Figure t-4. It makes a glancing collision with a second puck having a radius of 6cm and a mass of 120g (initially at rest) such that their rims just touch. Because their rims are coated with instant-acting glue, the pucks stick together and spin after the collision (Figure t-4). The systems center of mass velocity v_{cm} and the angular velocity about the center of mass *ω*, immediately after collision, are:

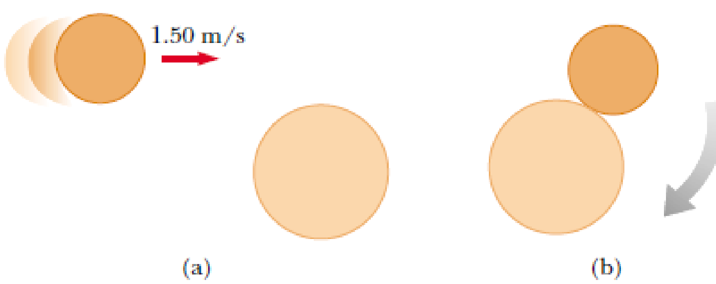

Figure t-4

a) $v_{cm} = 0{,}9m/s, \omega = 25{,}71rad/s$ b) $v_{cm} = 0{,}6m/s, \omega = 9{,}47rad/s$
c) $v_{cm} = 0{,}6m/s, \omega = 6{,}92rad/s$ d) $v_{cm} = 0{,}4m/s, \omega = 15.72rad/s$
e) $v_{cm} = 0{,}3m/s, \omega = 12{,}3rad/s$

5. A system consists of a ball resting at one and of a uniform board of length l, hinged at the other end, and elevated at an angle θ=π/4 (Figure t-5). A light cup is attached to the board at r_c so that it will catch the ball when the support stick is suddenly removed. The ball will fall into the cup when the board is supported at:

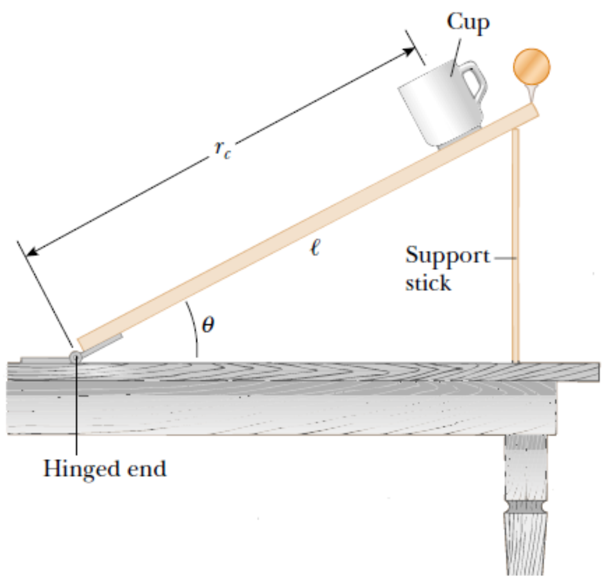

Figure t-5

a) $r_c = \frac{2}{3}l$

b) $r_c = \frac{\sqrt{2}}{2}l$

c) $r_c = \sqrt{\frac{3}{2}}l$

d) there is no such r_c

e) $r_c = \sqrt{\frac{2}{3}}l$

6. A sphere of mass *M* and radius *R* has a nonuniform density that varies with *r*, the distance from its center, according to the expression *ρ=Ar*, for 0≤*r*≤*R*. The dependence of the gravitational field intensity *G* on the radial coordinate *r* is:

a) $G = \begin{cases} \frac{\gamma M r}{R^3}, & r \in [0, R] \\ \frac{\gamma M}{r^2}, & r \in (R, \infty) \end{cases}$,

b) $G = \begin{cases} \frac{\gamma M r^3}{R^5}, & r \in [0, R] \\ \frac{\gamma M}{r^2}, & r \in (R, \infty) \end{cases}$,

c) $G = \begin{cases} \frac{\gamma M r^2}{R^4}, & r \in [0, R] \\ \frac{\gamma M}{r^2}, & r \in (R, \infty) \end{cases}$,

d) $G = \begin{cases} \frac{\gamma M R}{r^3}, & r \in [0, R] \\ \frac{\gamma M}{R^2}, & r \in (R, \infty) \end{cases}$,

e) $G = \begin{cases} \frac{\gamma M}{R r}, & r \in [0, R] \\ \frac{\gamma M}{r^2}, & r \in (R, \infty) \end{cases}$,

7. A light cubical container of volume a^3 is initially filled with a liquid. The mass of the liquid in the filled container is m_0. The container is initially supported by a light string of length L_0 to form a pendulum ($L_0 >> a$). The liquid is allowed to flow from the bottom of the container at a constant rate $dm/dt=b$. The period T as a function of time is:

a) $T \approx 2\pi\sqrt{\frac{L_0}{g}}, \quad t \in \left[0, \frac{m_0}{b}\right]$

b) $T = 2\pi\sqrt{\frac{L_0}{g}}\sqrt{1+\frac{bL_0 t}{2m_0 a}}, \quad t \in \left[0, \frac{m_0}{b}\right]$

c) $T = 2\pi\sqrt{\frac{L_0}{g}}\sqrt{1+\frac{a}{2L_0}-\frac{bat}{2m_0 L_0}}, \quad t \in \left[0, \frac{m_0}{b}\right]$

d)sistem nije linearni harmonijski oscilator

e) $T = 2\pi\sqrt{\frac{L_0}{g}}\sqrt{1-\frac{bat}{m_0 L_0}}, \quad t \in \left[0, \frac{m_0}{b}\right]$

8. Two waves are described by the equations:

$$y_1(x,t) = 5\sin(2x-10t)$$

and

$$y_2(x,t) = 10\cos(2x-10t)$$

where x is in meters and t is in seconds. The amplitude y_{r0} and phase ϕ of the resulting sinusoidal wave are:

a) $y_{r0} = \sqrt{5}, \varphi = 0{,}15\pi$

b) $y_{r0} = 5\sqrt{3}, \varphi = \frac{\pi}{6}$

c) $y_{r0} = 5, \varphi = \frac{\pi}{2}$

d) $y_{r0} = 5\sqrt{5}, \varphi = 0{,}35\pi$

e) $y_{r0} = 5\sqrt{3}, \varphi = \frac{\pi}{3}$

9. A tank with water slides down an inclined plain of angle α=30°. If the tank has acceleration a=2m/s the angle β formed by the water surface and the inclined surface is:

a) $\beta = \frac{\pi}{6}$

b) $\beta = 0{,}061\pi$

c) $\beta = 0{,}1\pi$

d) $\beta = 0{,}21\pi$

e) $\beta = \frac{\pi}{3}$

10. Two opened cylindrical reservoirs with diameters D_1=3m and D_2=4m stand on a horizontal surface. The reservoirs are in touch by their lateral sides. Just above the bottom of the reservoirs, at the place where they touch, there is a small circular aperture with diameter d=10cm, which allows the transfusion of liquids stored in the reservoirs. If the liquid level in the first reservoir is H, and the second reservoir is empty, the time τ required for liquid levels in reservoirs to become equal is:

a) $\tau = 908{,}67s$ b) $\tau = 1615{,}42s$ c) $\tau = 327{,}12s$
d) $\tau = 581{,}55s$ e) $\tau = 231{,}01s$

11. An electric current of intensity I_1=1A flows through a tungsten wire in a vacuum packed light bulb. The wire has a temperature T_1=1000K. When the current is increased to I_2=3A the bulb power becomes 25 times higher. The tungsten wire is considered as a gray body with emission coefficient ϵ independent of temperature. The specific resistance of tungsten wire at temperature T_1 is ρ_1=25,710Ωm. The wire temperature T_2 that corresponds to the current I_2 and the specific resistivity ρ_2 at this temperature are:

a) $T_2 = 2236{,}07K,\ \rho_2 = 71{,}39\times10^{-8}\,\Omega m$ b) $T_2 = 5000K,\ \rho_2 = 42{,}85\times10^{-8}\,\Omega m$
c) $T_2 = 3000K,\ \rho_2 = 214{,}25\times10^{-8}\,\Omega m$ d) $T_2 = 1666{,}67K,\ \rho_2 = 9{,}25\times10^{-8}\,\Omega m$
e) $T_2 = 2236{,}07K,\ \rho_2 = 42{,}85\times10^{-8}\,\Omega m$

12. The chemical composition of the atmosphere is changed with altitude because the various molecules have different masses. Starting from the expression for the pressure gradient:

$$\frac{dp}{dz} = -m_0 gn$$

where m_0 is the mass of the single molecule and n is their concentration, determine (in percents) for how much is the ratio of oxygen to nitrogen molecules changed between 10km and see level . Assume a uniform temperature of 300K, and take the molecular masses to be 32g/mol for oxygen (O_2) and 28g/mol for nitrogen (N_2) (N_A=6,022×10^{23}, k_B=1,38×$10^{-23}$$m^2kg/s^2K$).

a) $\delta = 8{,}51\%$ b) $\delta = 98{,}40\%$ c) $\delta = 20\%$
d) $\delta = 9{,}84\%$ e) $\delta = 85{,}13\%$

13. On a cold winter day a man puts in his pocket m_1=9g of copper coins (c_{Cu}=385J/kg°C) at temperature t_1=-12°. The pocket already contains m_2= 14g of silver coins (c_{Ag}=235J/kg°C) at temperature t_2=30°. If the temperature of the copper coins is increasing with a constant rate of b_{Cu}=0.5°C/s with what rate b_{Ag} is the temperature of the silver coins changing? Calculate the change in entropy ΔS of the system. Neglect energy transferred to the surroundings.

a) $b_{Ag} = 0{,}53;\ \Delta S = 0{,}504\,J/^\circ C$ b) $b_{Ag} = 0{,}47;\ \Delta S = 0{,}0184\,J/^\circ C$
c) $b_{Ag} = 0{,}19;\ \Delta S = 0{,}504\,J/^\circ C$ d) $b_{Ag} = 0{,}53;\ \Delta S = -0{,}0184\,J/^\circ C$
e) $b_{Ag} = 0{,}53;\ \Delta S = 0{,}0184\,J/^\circ C$

14. Figure t-14 represents n mol of an ideal monatomic gas being taken trough a cycle that consists of two isothermal processes at temperatures $3T_i$ and T_i and two constant-volume processes. The efficiency of an engine operating in this cycle is:

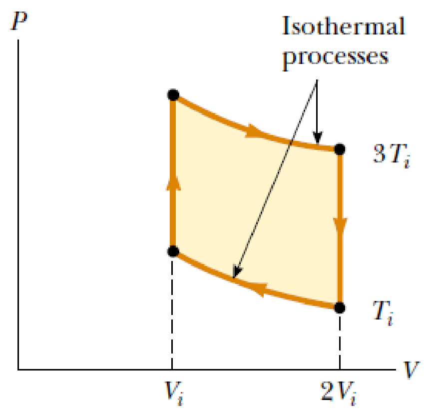

Figure t-14

a) $\eta = 43{,}49\%$ b) $\eta = 40{,}93\%$ c) $\eta = 21{,}25\%$
d) $\eta = 27{,}3\%$ e) $\eta = 61{,}39\%$

15. A rearview mirror in cars consists of a reflective coating on the back of a rectangular glass prism with angle α and index of refraction n. In the day setting the rearview mirror is vertical and the figure is formed by the light reflected from the back surface (Figure t-15). The night setting greatly diminishes the intensity of image in order that lights from trailing vehicles do not blind the driver. In this case the rearview mirror is rotated so that the image is formed from the light reflected from the front surface (Figure t-15). The angle θ for witch the rearview mirror is rotated at night is:

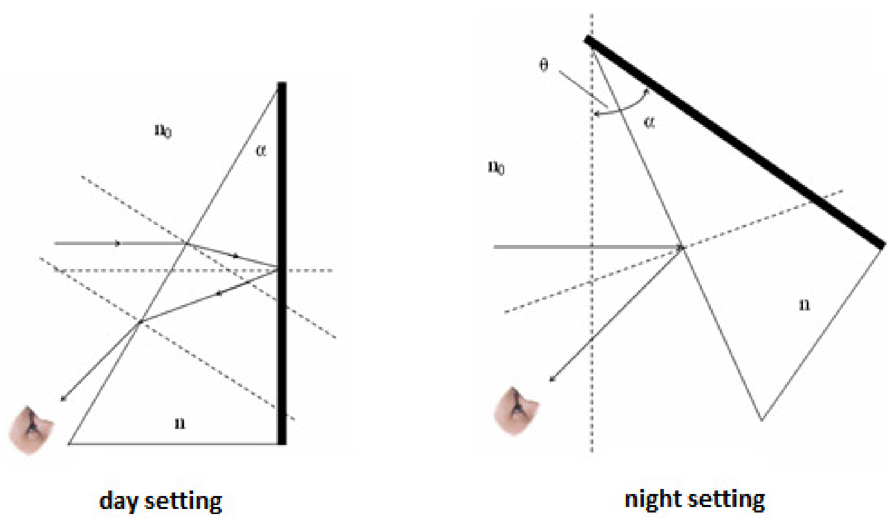

Figure t-15

a) $\theta = (2n-1)\alpha$ b) $\theta = 2(n-1)\alpha$ c) $\theta = n\alpha$
d) $\theta = (n-1)\alpha$ e) $\theta = (2n+1)\alpha$

16. A gold fish is swimming inside a spherical plastic bowl with radius *R*=15cm filled with water that has index of refraction *n*= 1.33. If the goldfish is located 10cm from the wall of the bowl on a horizontal axis that goes through the its center of, where does it appear to an observer outside the bowl?

a) $l = 9cm$ b) $l = 6{,}45cm$ c) $l = 10cm$
d) $l = 13{,}3cm$ e) $l = 3{,}3cm$

17. Two radio antennas separated by 300m as shown in Figure t-17 simultaneously broadcast identical signals at the same wavelength. The antennas are located at distance 1000m from the road. A radio in a car traveling along the road starting from the point O for the first time receives strong signal at a distance 200m from this point. The wavelength of the radio signal is:

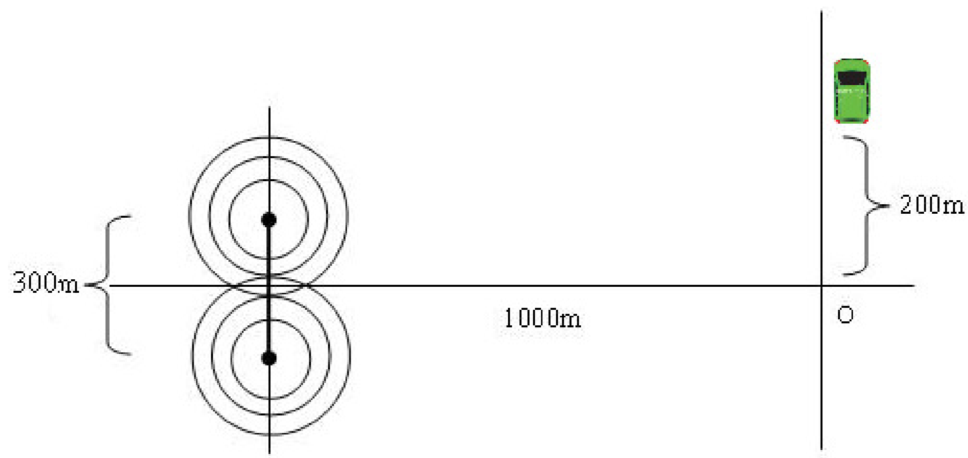

Figure t-17

a) $\lambda = 60m$ b) $\lambda = 58{,}23m$ c) $\lambda = 30m$
d) $\lambda = 116{,}46m$ e) $\lambda = 60m$

18. Three linear polarizers are placed in line, one after the other, as it is shown in Figure t-18. Transmission axes of the first and third polarizer are perpendicular to each other. The second polarizer is rotating around central axis with constant angular velocity *ω*. The transmission axis of the second polarizer initially coincides with transmission axis of the first polarizer. If unpolarized light with intensity I_i is incident on the left disk the intensity of the beam emerging from the right disk I_t is:

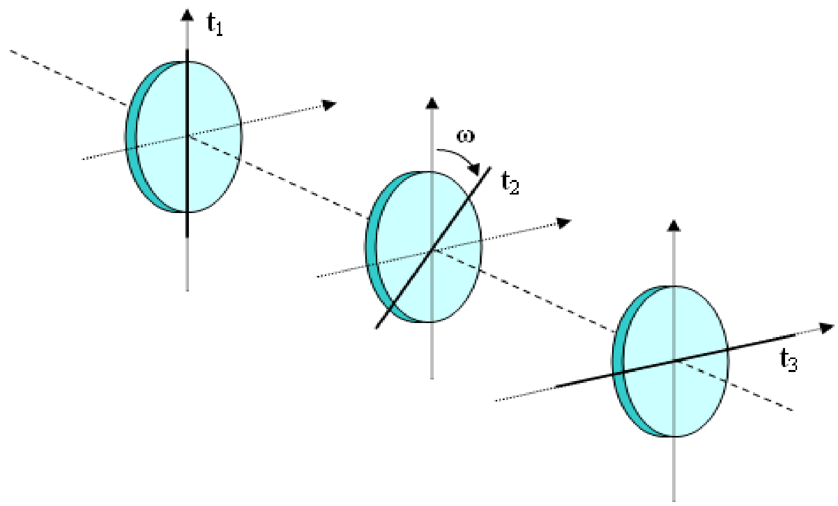

Figure t-18

a) $I_t = \frac{I_i}{8}(1+\cos 4\omega t)$ b) $I_t = \frac{I_i}{8}(1-\cos 4\omega t)$ c) $I_t = \frac{I_i}{16}(1+\sin 4\omega t)$

d) $I_t = \frac{I_i}{16}(1+\cos 4\omega t)$ e) $I_t = \frac{I_i}{8}\sin^2 4\omega t$

19. Iridium nucleus makes a transition from primary to an excited state emitting a photon of energy 130keV. Find the velocity *v* of the nucleus after the transition if its mass is 3.2×10^{-25} kg?

20. Radioactive isotope $^{224}_{84}X$ transforms to the isotope $^{212}_{79}Y$ through N_α alpha and N_β beta minus (β^-) decays. The number of realized α and β^- decays is:

a) $N_\alpha = 3, N_\beta = 1$ b) $N_\alpha = 3, N_\beta = 2$ c) $N_\alpha = 2, N_\beta = 2$

d) $N_\alpha = 1, N_\beta = 4$ e) $N_\alpha = 4, N_\beta = 3$

Note: Each task carries 5 points. Only correctly circled reply with detailed procedure and adequate explanation will be marked with a full number of points. For incorrectly circled reply procedure is not taken into account.