PHYS121 2023-2024 Fall Semester
Final Exam Time: 90 minutes

1	2	3	4	5	Toplam

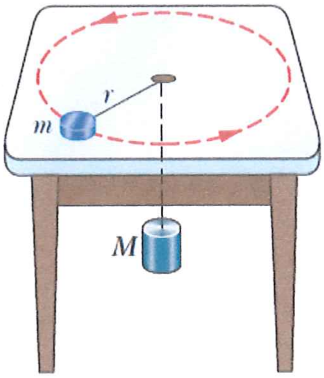
Student No:...

Name Surname:.. Lecturer:...

You can use calculator during the exam, but exchanging is not allowed.

Unless stated otherwise, take g = 9.80 m/s^2 if necessary. Each question worth 20 points. **Good luck**

1. A puck of mass $m = 1.50$ kg slides in a circle of radius $r = 20.0$ cm on a frictionless table while attached to a hanging cylinder of mass $M = 2.50$ kg by means of a cord that extends through a hole in the table. What speed keeps the cylinder at rest?



The cylinder is at rest if

$$Mg = m\frac{v^2}{r}$$ 5 puan

$$v^2 = \frac{Mgr}{m}$$

$$v = \sqrt{\frac{Mgr}{m}}$$ 5 puan

$r = 20\,cm = 0{,}2\,m$

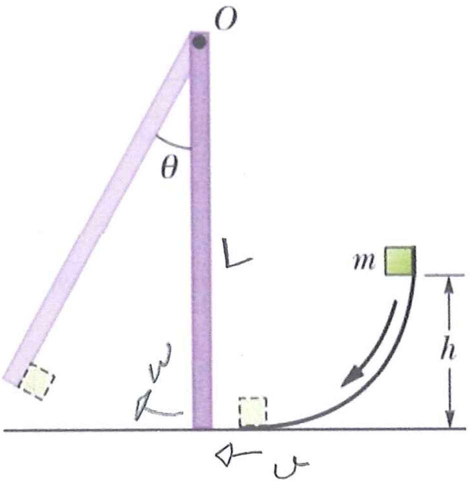
5 puan

r'yi doğru olmalı

$$v = \sqrt{\frac{2{,}50 \times 9{,}80 \times 0{,}2}{1{,}50}} = 1{,}81\ \frac{m}{s}$$

5 puan nümerik sonuç

2. In the figure, a small 50 g block slides down a frictionless surface through height $h = 20$ cm and then sticks to a uniform rod of mass 100 g and length 40 cm. The rod pivots about point O and is initially at rest. With what angular speed will the rod start its rotation? You may treat the block as a point particle. (The moment of inertia about the end of a rod is given by $I = \frac{1}{3}ML^2$, where M is the mass, and L the length of the rod.)



$m = 50\,g = 50\times10^{-3}$ kg

$M = 100\,g = 0{,}100$ kg

$L = 40$ cm $= 0{,}40$ m

$h = 20$ cm $= 0{,}20$ m

No friction, mechanical energy conserved — 5 puan (mekanik enerjinin korunumu)

$\Delta U + \Delta K = 0$

$(0 - mgh) + \frac{1}{2}mv^2 = 0$

$v = \sqrt{2gh}$ — speed just before the collision

During the collision, angular momentum conserved

$I_{total} = mL^2 + \frac{1}{3}ML^2$ — 5 puan (Eylemsizlik momenti)

$L_f = L_{initial}$ — 5 puan (açısal momentum korunumu)

$I\omega = mvL$

$$\omega = \frac{mvL}{I} = \frac{m\sqrt{2gh}\,L}{mL^2 + \frac{1}{3}ML^2} = \frac{\sqrt{2gh}}{L + \frac{1}{3}\frac{M}{m}L} = \frac{\sqrt{2gh}}{L\left(1+\frac{1}{3}\frac{M}{m}\right)}$$

$$\omega = \frac{\sqrt{2\times9{,}80\times0{,}2}}{0{,}4\left(1+\frac{1}{3}\cdot\frac{100}{50}\right)} = \frac{3\sqrt{0{,}4\times9{,}8}}{2}\ \frac{rad}{s}$$

($1+\frac{1}{3}\cdot2 = 5/3$)

5 puan — Girip nümerik sonuç bulmak

$\omega = 3{,}0\ \frac{rad}{s}$ (2 significant figures)

3. An object is undergoing a simple harmonic motion with period 0.300 s and amplitude 6.00 cm. At $t = 0$ the object is instantaneously at rest at $x = 6.00$ cm. Calculate the (a) motion's frequency f, and (b) angular frequency ω. (c) Find the time it takes the object to go from $x = 6.00$ cm to $x = -1.50$ cm.

$T = 0{,}300\,s$

$A = 6.00\,cm$

$x(t) = A\cos(\omega t)$, $t=0,\ x = A = 6{,}0\,cm$

$v = \left.\frac{dx}{dt}\right|_{t=0} = -\omega A \sin(0) = 0$

initial phase is "0"

(a) $f = \frac{1}{T} = \frac{1}{0{,}3}\,s^{-1} = 3{,}33\,s^{-1}$ ✓ 4 puan

(b) $\omega = \frac{2\pi}{T} = \frac{2\pi}{0{,}3}\,\frac{rad}{s} = \frac{20\pi}{3}\,\frac{rad}{s}$ ✓ 4 puan

$= 20{,}9\ rad/s$

(c) $x(t) = (6{,}00\,cm)\cos\left(\frac{20\pi}{3}t\right)$ ✓ 4 puan

Faz açısının "0" olduğunu farketmek

$x(t_i) = 6{,}00\,cm = (6{,}00\,cm)\cos\left(\frac{20\pi}{3}t_i\right) \Rightarrow t_i = 0$

$x(t_f) = -1{,}50\,cm = (6{,}00\,cm)\cos\left(\frac{20\pi}{3}t_f\right)$ ✓ 4 puan

$\cos\left(\frac{20\pi}{3}t_f\right) = -\frac{1}{4}$

$t_f = \frac{3}{20\pi}\cos^{-1}\left(-\frac{1}{4}\right) = 0{,}0871\,s$

✓ 4 puan

$\Delta t = t_f - t_i = 0{,}0871\,s$

4. A transverse harmonic wave travels on a rope according to the following expression: $y(x,t) = 0.2\sin(2.4x + 18t)$, where the distances are in meters, and the time is in seconds. The mass density of the rope is $\mu = 0.1$ kg/m

a) What is the travelling direction of the wave?

b) What is the amplitude of the wave?

c) What is the period of the wave?

d) What is the wavelength of the wave?

e) What is the tension on the rope?

f) At $x = 0.3$ m and $t = 0.5$ s, what are the velocity and acceleration of the rope?

General formula

$y(x,t) = A\sin(kx+wt)$ wave in −x-direction

$y(x,t) = A\sin(kx-wt)$ wave traveling in +x-direction

(a) −x-direction. 2 puan

(b) $A = 0{,}2$ m 2 puan

(c) $W = 18\ \frac{rad}{s}$ 2 puan $\Rightarrow T = \frac{2\pi}{w} = \frac{2\pi}{18}\ s = \frac{\pi}{6}\ s$ 2 puan

(d) $k = 2{,}4\ m^{-1}$ 2 puan $\Rightarrow \lambda = \frac{2\pi}{k} = \frac{2\pi}{2{,}4} = \frac{\pi}{1{,}2}\ m = \frac{5\pi}{6}\ m$ 2 puan

(e) $v = \frac{w}{k} = \sqrt{\frac{F}{\mu}}$ 2 puan $\Rightarrow F = \mu \cdot \left(\frac{w}{k}\right)^2$ 2 puan

$F = 0{,}1\ \frac{kg}{m} \cdot \left(\frac{18\ m}{2{,}4\ s}\right)^2 = 5{,}625\ kg\ \frac{m}{s^2} = 5{,}625\ N$

(f) $v_y = \frac{dy}{dt} = 3{,}6\cos(2{,}4x + 18t)$ 2 puan

$= 3{,}6\cos(2{,}4 \cdot 0{,}3 + 18 \cdot 0{,}5) = -3{,}44$ m/s

$a = \frac{dv_y}{dt} = -64{,}8\sin(2{,}4x + 18t)$ 2 puan

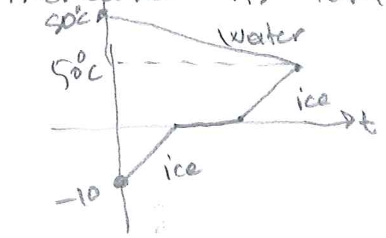
$= -64{,}8\sin(2{,}4 \cdot 0{,}3 + 18 \cdot 0{,}5)$

$= 18{,}85\ m/s^2$

5. A thermally insulated container with negligible mass contains 0.50 kg of water at a temperature of 80.0°C. How many kilograms of ice cubes at a temperature of −10.0°C must be put into the water to make the final temperature of the system 50.0°C?

(The specific heat of water $c_{water} = 4190$ J/kg·K, the specific heat of ice $c_{ice} = 2100$ J/kg·K, and the latent heat of fusion of water $L_f = 334 \times 10^3$ J/kg.)

ice must heat up to 0°C then melts. Finaly it should increase its temperature to 50°C



$\Sigma \Delta Q = 0$ 3 puan

$m_{ice} \cdot C_{ice} \cdot (0-(-10))$ [3 puan] $+ m_{ice} \cdot L_f$ [3 puan]

$+ m_{ice} \cdot C_{water} \cdot (50-0)$ [3 puan] $+ m_{water} \cdot C_{water} \cdot (50-80) = 0$ [3 puan]

$$m_{ice} = \frac{m_{water} \cdot 30 \cdot C_{water}}{10\, C_{ice} + L_f + 50 \cdot C_{water}}$$ 3 puan

$$m_{ice} = \frac{0{,}50 \cdot 30 \cdot 4190}{10 \cdot 2100 + 334 \times 10^3 + 50 \cdot 4190} \text{ kg}$$

$m_{ice} = 0{,}111$ kg 2 puan nümerik sonuç

Denklemdeki her terim 3'er puan