PHYS 101: General Physics 1 **KOÇ UNIVERSITY** **Spring Semester 2016**

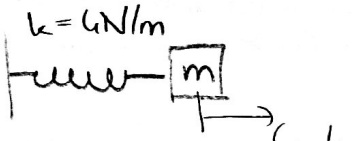
College of Sciences

Section 1 **Quiz 11** **April 29, 2016**

Closed book. Duration: 10 minutes

Name: **Student ID:** **Signature:**

A body of mass $m = 1$ kg is attached to a wall by a spring of constant $k = 4$ N/m. It is given an initial velocity, at $x = 0$ cm (its equilibrium position), of 6 m/s. Plot the time evolution of the displacement $x(t)$, velocity $v(t)$ and acceleration $a(t)$ for one period.



$x(t) = A\cos(\omega t + \phi)$ → ϕ to be determined

$v(t) = -A\omega \sin(\omega t + \phi)$

$a(t) = -A\omega^2 \cos(\omega t + \phi)$

$x(0) = 0$

$v(0) = 6\,m/s = -A\omega \sin\left(-\frac{\pi}{2}\right) = A\omega$ → $\phi = -\frac{\pi}{2}$

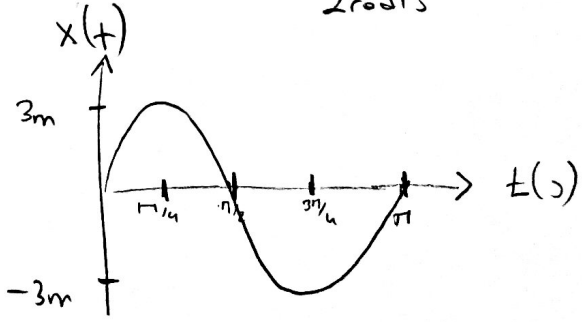
$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{4\,N/m}{1\,kg}} = 2\ rad/s$ $\quad A = \frac{6\,m/s}{2\,rad/s} = 3m$

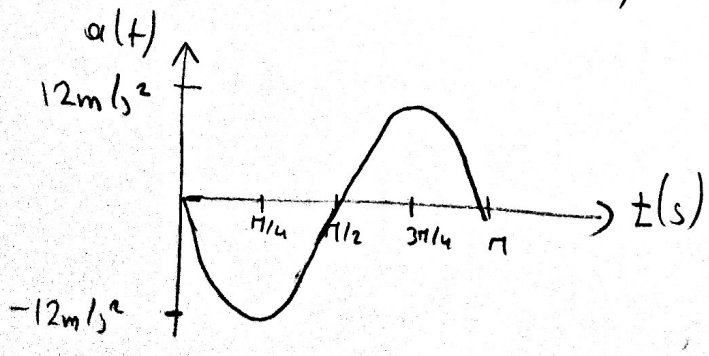
$T = 2\pi/\omega = \pi$ seconds

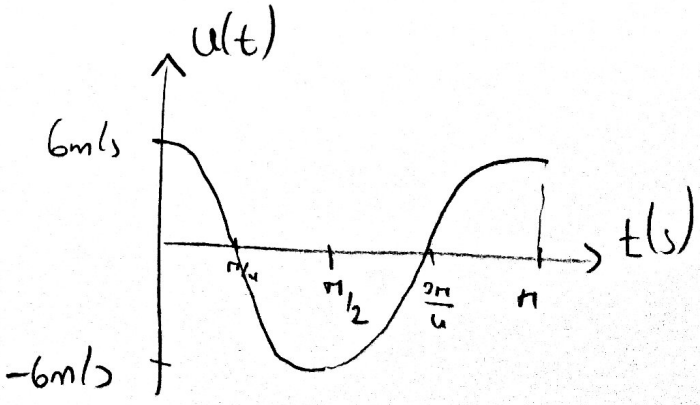
$x(t) = 3m \sin(2t)$

$v(t) = 6m/s \cos(2t)$

$a(t) = -12m/s^2 \sin(2t)$







PHYS 101: General Physics 1 **KOÇ UNIVERSITY** **Spring Semester 2016**

College of Arts and Sciences

Section 2 **Quiz 11** **April 29, 2016**

Closed book. Duration: 10 minutes

Name: Ongun ARISEV **Student ID:** **Signature:** Ongun Arisev

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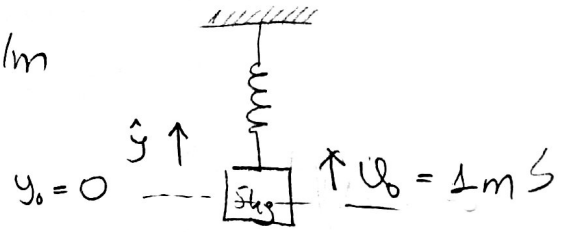
A spring stretches 10 cm when its tension is 50 N. A body of mass 5 kg is hung from the spring. When at rest the body is given an initial upward velocity of 1 m/s. (Take $g = 10\,m/s^2$) (i) Find the amplitude and the frequency of the motion. (ii) Find the acceleration of the mass when it is 5 cm above its equilibrium position. (iii) Find the force of tension in the spring at this point.

$$k = \frac{50N}{10cm} = 500\,N/m$$



As always

$y(t) = A\cos(\omega t + \phi)$

$v(t) = -A\omega\sin(\omega t + \phi) \Rightarrow \phi = -\frac{\pi}{2}$ (initial vel. is positive) $\Rightarrow v(t) = A\omega\cos(\omega t)$

$a(t) = -A\omega^2\cos(\omega t + \phi) = -\omega^2 y(t)$

(i) $\omega = \sqrt{\frac{k}{m}} \Rightarrow f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = \frac{1}{2\pi}\sqrt{\frac{500N/m}{5kg}} = \frac{5}{\pi}\ Hz$

$A\omega = 1\,m/s$ $\omega = 10\,rad/s \Rightarrow A = 0.1\,m$

(ii) $a(5cm) = -\omega^2\,5cm = -100\frac{rad}{s}0.05m = -5\,m/s^2$

(iii) $T_{spring} - mg = ma \Rightarrow T_{spring} - 50N = -25N$

$T_{spring} = 25N$

PHYS 101: General Physics 1 **KOÇ UNIVERSITY** **Spring Semester 2016**

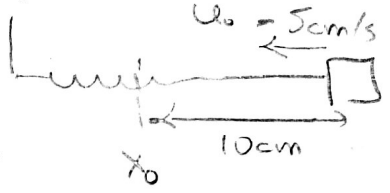
College of Arts and Sciences

Section 3 **Quiz 11** **April 29, 2016**

Closed book. Duration:10 minutes

Name: **Student ID:** **Signature:**

A body in simple harmonic motion with angular frequency $\omega = 0.5$ rad/s is initially 10 cm away from its equilibrium position and moving back toward the equilibrium position with a velocity 5 cm/s. (i) Find the period of the motion. (ii) Find the coordinate and velocity of the body as a function of time. (iii) How long does it take the body to return to its equilibrium position?



$x(t) = A\cos(\omega t + \phi)$ $\quad x(0) = 10\text{cm}$

$v(t) = -A\omega\sin(\omega t + \phi)$ $\quad v(0) = -5\text{cm/s}$

$a(t) = -A\omega^2\cos(\omega t + \phi)$

i) $\omega = 0.5\text{rad/s}$ $\quad T = \frac{2\pi}{\omega} = 4\pi$ seconds

$+10\text{cm} = A\cos(\phi)$

$-5\text{cm/s} = -A\omega\sin(\phi)$

$10\text{cm} = A\sin(\phi)$ $\quad \tan(\phi) = 1$ $\quad \phi = \frac{\pi}{4}$

$10\text{cm} = A\frac{\sqrt{2}}{2} \Rightarrow$ $\quad A = 10\sqrt{2}\text{cm}$

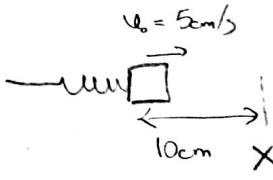
(ii) $x(t) = (10\sqrt{2}\,\text{cm})\cos(\omega t + \frac{\pi}{4})$ $\quad \omega = 0.5\text{rad/s}$

$v(t) = (-5\sqrt{2}\,\text{cm/s})\sin(\omega t + \frac{\pi}{4})$

(iii) $x(t_{return}) = 0 = (10\sqrt{2}\text{cm})\cos(\omega t_{return} + \frac{\pi}{4})$

$\omega t_{return} = \frac{\pi}{4} \Rightarrow$ $\quad t_{return} = \frac{\pi}{2}$ seconds $\Rightarrow$

Alternative solution



$-10cm = A\cos(\phi)$

$+5m/s = -A\omega\sin(\phi)$

(i) $T = \frac{2\pi}{\omega} = 4\pi$ seconds

$-10cm = A\cos(\phi)$

$-10cm = A\sin(\phi)$ $\quad \tan(\phi) = 1$

$\phi = \frac{\pi}{4} + k\pi \quad \phi = \frac{5\pi}{4} = 225°$

k is integer

Should lie in the third quadrant since $x<0, y<0$

$-10\,cm = A\cos(\frac{5\pi}{4}) \Rightarrow A = 10\sqrt{2}$

(ii)

$x(t) = 10\sqrt{2}\,cm\,\cos(\omega t + \frac{5\pi}{4})$

$v(t) = -5\sqrt{2}\,cm/s\,\sin(\omega t + \frac{5\pi}{4})$

(iii) $x(t_{return}) = 0 = \cos(\omega t_{return} + \frac{5\pi}{4})$

$\omega t_{return} + \frac{5\pi}{4} = \frac{3\pi}{2}$

$\omega t_{return} = \frac{\pi}{4}$

$t_{return} = \frac{\pi}{2}$