NATIONAL UNIVERSITY OF COMPUTER AND EMERGING SCIENCES FAST

National University of Computer & Emerging Sciences, Karachi

Fall-2020 CS-Department

Mid Term II

25th November, 2020, (12:00 pm – 1:00pm)

Course Code: EE (117)	**Course Name: Applied Physics**
Instructor Name / Names: Ms. Rabia Tabassum, Mr. Abdul Saboor Khan, Mr. Muhammad Adeel, Waqar Ahmed	
Student Roll No:	**Section :**

Instructions:

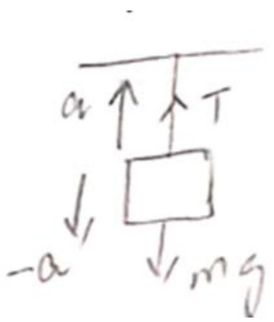
- Return the question paper with your answer sheet.
- Read each question completely before answering it. There are **3 questions and 2 pages.**
- All the answers must be solved according to the sequence given in the question paper.

Time: 60 minutes. **Max Marks**: 45 points

Question: 1(Force and Newton's Laws) [10]

a) An elevator cab that weighs 27.8 kN moves upward. What is the tension in the cable if the cab's speed is (i) increasing at a rate of 1.22 m/s^2 and (ii) decreasing at a rate of 1.22 m/s^2? [4]

Solution:



(a) The mass of the elevator is $m = (27800/9.80) = 2837$ kg and (with $+y$ upward) the acceleration is $a = +1.22$ m/s^2. Newton's second law leads to

$$T - mg = ma \;\Rightarrow\; T = m(g + a)$$

which yields $T = 3.13 \times 10^4$ N for the tension.

(b) The term "deceleration" means the acceleration vector is in the direction opposite to the velocity vector (which the problem tells us is upward). Thus (with $+y$ upward) the acceleration is now $a = -1.22$ m/s^2, so that the tension is

$$T = m\,(g + a) = 2.43 \times 10^4 \text{ N}.$$

b) In Fig-1, a force acts on a block weighing 45 N. The block is initially at rest on a plane inclined at angle $\theta = 15°$ to the horizontal. The positive direction of the x axis is up the plane. Between block and plane, the coefficient of static friction is $\mu_s = 0.50$ and the coefficient of kinetic friction is $\mu_k = 0.34$. In unit-vector notation, what is the frictional force on the block from the plane when $\vec{P}$ is **−5.0 N** [4]

Solution:

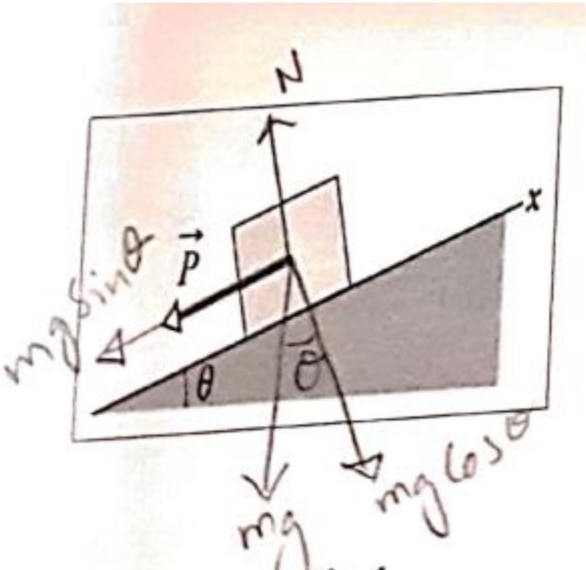


Fig-1

(a) For $\vec{P} = (-5.0\text{ N})\hat{\text{i}}$, Newton's second law, applied to the *x* axis becomes

$$f - |P| - mg\sin\theta = ma.$$

Here we are assuming $\vec{f}$ is pointing uphill, as shown in Figure 6-5, and if it turns out that it points downhill (which *is* a possibility), then the result for f_s will be negative. If $f = f_s$ then $a = 0$, we obtain

$$f_s = |P| + mg\sin\theta = 5.0\text{ N} + (43.5\text{ N})\sin 15° = 17\text{ N},$$

or $\vec{f}_s = (17\text{ N})\hat{\text{i}}$. This is clearly allowed since f_s is less than $f_{s,\max}$.

OR

At rest:

$N - mg\cos\theta = 0$ | $-mg\sin\theta - P + f_s = 0$

$\boxed{N = mg\cos\theta}$ — (1) | $f_s = mg\sin\theta + P$ -

Since $f_s = \mu_s N$ (max friction) For start moving:

$= 0.5(45)\cos 15^\circ$

$\boxed{f_s = 21.7\ N}$

$f - P - mg\sin\theta = ma$

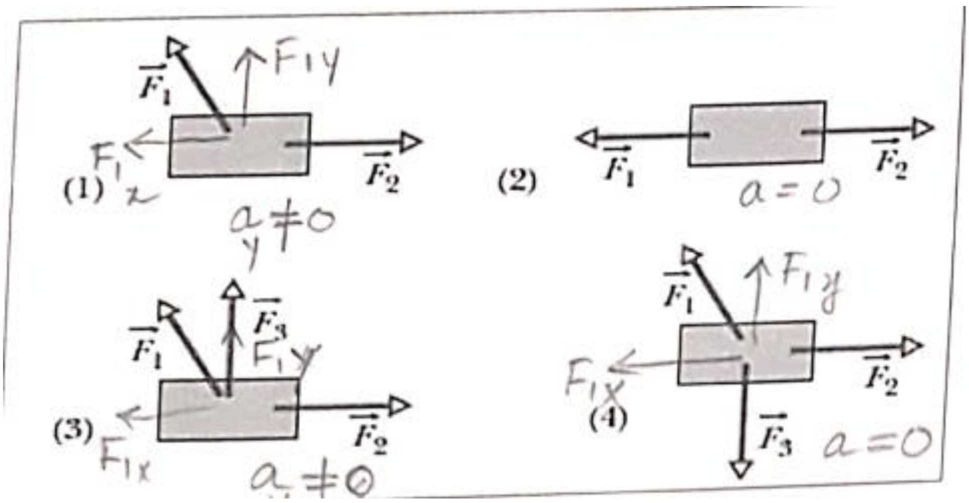
If $f = f_s$ when $a = 0$

$f = P + mg\sin\theta = 5 + 45(\sin 15)$

$\boxed{f = 16.64\ N}$ which is less then max friction

c) Fig-2 shows overhead views of four situations in which forces act on a block that lies on a frictionless floor. If the force magnitudes are chosen properly, in which situations is it possible that the block is (i) stationary and (ii) moving with a constant velocity? [2]

Solution:

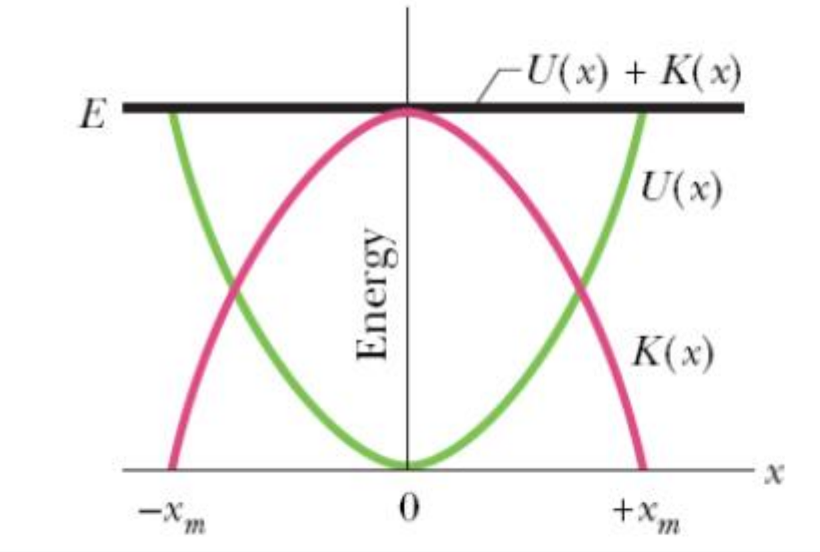


Question: 2(Simple Harmonic Motion) [15].

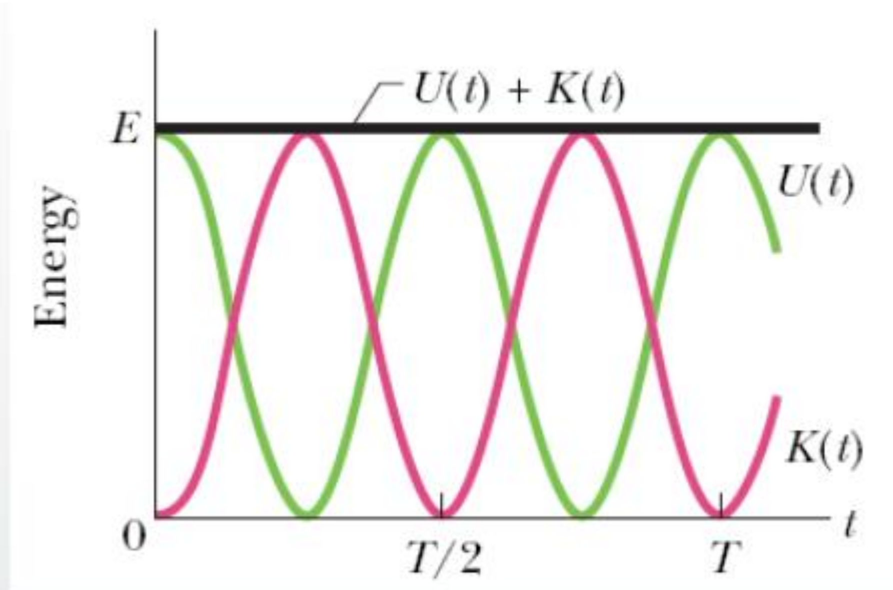
a) Explain how kinetic energy "K" and potential energy "U" change with respect to position "x", with help of graph between (i) Energy and Position (ii) Energy and Time .(Only graphs) [2]

Solution:

(i) Energy and Position

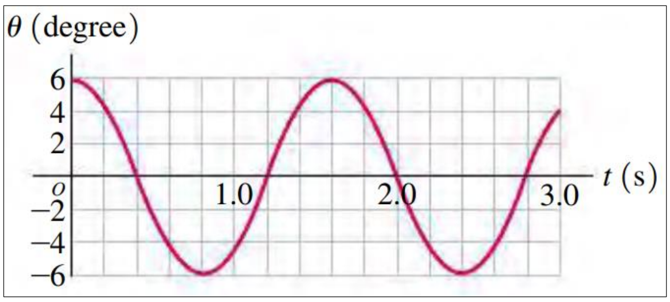


(ii) Energy and Time



b) In the laboratory, a student studies a pendulum by graphing the angle θ that the string makes with the vertical as a function of time t, obtaining the graph shown in Fig-3. (i) What are the period, frequency, and amplitude of the pendulum's motion? (ii) How long is the pendulum? [4]

Solution:



(i) $T = 1.6\ sec$

$f = \frac{1}{2} = 0.625\ Hz$

$a = 6$

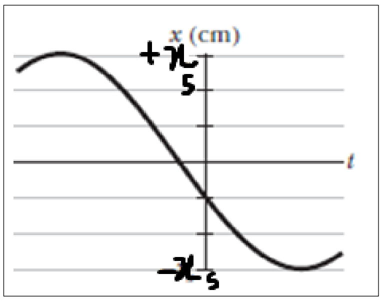
Fig-3

(ii) $T = 2\pi\sqrt{\frac{L}{g}} = T^2 = 4\pi^2 \frac{L}{g} \Rightarrow L = \frac{T^2 g}{4\pi^2}$

$L = \frac{(1.6)^2(9.8)}{4(3.14)^2} \Rightarrow \boxed{L = 0.635m}$

c) What is the phase constant for the harmonic oscillator with the position function x(t) given in Fig-4 if the position function has the form $x = x_m \cos(\omega t + \varphi)$? The vertical axis scale is set by $x_s = 6.0$ cm. [2]

Solution:



From graph:

$x_m = 6cm$

at $t = 0$ $x = -2$

therefore, $-2 = 6\cos(0 + \phi) \Rightarrow \cos\phi = -\frac{\cancel{2}^{1}}{\cancel{6}_{3}}$

$\theta = \cos^{-1}\left(\frac{-1}{3}\right) \Rightarrow \boxed{\theta = \quad}$

d) What are the frequencies of Ultrasonic and Infrasonic sounds? Who can hear the Ultrasonic and Infrasonic Sounds (Give examples)? [3]

Solution:

Sounds above 20,000 Hz are termed ultrasonic. Some animals, such as dogs, can hear frequencies in this range in which humans cannot hear

A healthy human ear can hear frequencies in the range of 20 Hz to 20,000 Hz. Humans cannot hear below 20 Hz. Sounds below this frequency are termed infrasonic. Human Ear cant hear this sound but **elephants** and **whales** can hear this

e) An oscillator consists of a block attached to a spring (k=400 N/m). At some time t, the position (measured from the system's equilibrium location), velocity, and acceleration of the block are x =0.100 m, v =13.6 m/s, and a= -123 m/s^2. Calculate (i) the frequency of oscillation, (ii) the mass of the block, and (iii) the amplitude of the motion [4]

Solution:

17. (a) Equation 15-8 leads to

$$a=-\omega^2 x \Rightarrow \omega=\sqrt{\frac{-a}{x}}=\sqrt{\frac{123 \text{ m/s}^2}{0.100 \text{ m}}}=35.07 \text{ rad/s}.$$

Therefore, $f=\omega/2\pi = 5.58$ Hz.

(b) Equation 15-12 provides a relation between ω (found in the previous part) and the mass:

$$\omega=\sqrt{\frac{k}{m}} \Rightarrow m=\frac{400 \text{ N/m}}{(35.07 \text{ rad/s})^2}=0.325\text{kg}.$$

(c) By energy conservation, $\frac{1}{2}kx_m^2$ (the energy of the system at a turning point) is equal to the sum of kinetic and potential energies at the time t described in the problem.

$$\frac{1}{2}kx_m^2=\frac{1}{2}mv^2+\frac{1}{2}kx^2 \Rightarrow x_m=\frac{m}{k}v^2+x^2.$$

Consequently, $x_m=\sqrt{(0.325 \text{ kg}/400 \text{ N/m})(13.6 \text{ m/s})^2+(0.100 \text{ m})^2}=0.400$ m.

Question: 3(Wave Motion) [20]

a) Can a wave be both transverse and longitudinal? Give example. [3]

Solution:

The motion of water molecules on the surface of deep water in which a wave is propagating is a combination of transverse and longitudinal displacements OR Water Wave

b) Two identical traveling waves, moving in the same direction, are out of phase by $\pi/2$ rad. What is the amplitude of the resultant wave in terms of the common amplitude y_m of the two combining waves? [4]

Solution:

$$y'(x,t) = \underbrace{[2y_m \cos \tfrac{1}{2}\phi]}_{\text{Magnitude gives amplitude}} \underbrace{\sin(kx - \omega t + \tfrac{1}{2}\phi)}_{\text{Oscillating term}}$$

two

sinu-

OR

Maybe it would be enough to use

$$y'_{max} = |2y_{max}cos(\frac{1}{2}\phi)|$$

If you just replace ϕ with 90 degrees the cosine will became $\frac{\sqrt{2}}{2}$

Simplifying, the ratio is now

$$\frac{y'_{max}}{y_{max}} = \sqrt{2}$$

c) A sinusoidal wave train is described by the equation

y = (0.25m) Sin(0.3x-40t)

where x and y are in meters and t is in seconds. Determine for this wave the (i) Time period, (ii)frequency, (iii) Wavelength , (iv)Wave speed and (v) Transverse velocity u at x=22.5cm at time t=18.9s (vi) Transverse acceleration at x=22.5cm at time t=18.9s? [8]

Solution:

$x_m = 0.25m$

$k = 0.3$

$W = 40$

(i) $T = \frac{2\pi}{\omega} = \frac{2(3.14)}{40} \Rightarrow \boxed{T =\quad}$

(ii) $f = \frac{1}{T} \Rightarrow \boxed{f =\quad}$

(iii) $\lambda = \frac{2\pi}{K} = \frac{2(3.14)}{0.3} = \boxed{\lambda =\quad}$

(iv) $v = \frac{W}{K} = \frac{40}{0.3} \quad \boxed{v =\quad}$

(v) $u = -(0.25)\times(40)\,Cos(0.3x - 40t) = \boxed{u =\quad}$

(vi) $a = -0.25(40)^2 Sin(0.3x - 40t)$

$\boxed{a =\quad}$

d) A pulse moving to the right along the x axis is represented by the wave function:

$$\mathbf{y\ (x,\ t)} = \frac{\mathbf{2}}{(\boldsymbol{x}-\mathbf{3.0}\boldsymbol{t})^{\mathbf{2}}+\mathbf{1}}$$

where, x and y are measured in centimeters and t is measured in seconds. Plot the wave function at t = 0, t = 1.0 s and t = 2.0 s. [5]

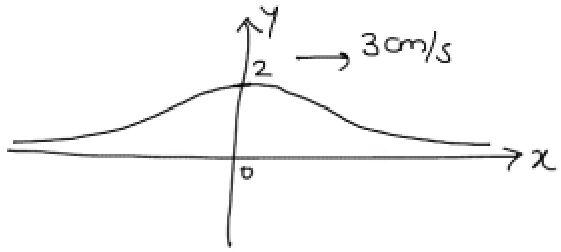
Solution

a)1 $t=0$

$$y = \frac{2}{x^2+1}$$

at $x=0$

$$Y_0 = 2\text{ cm}$$



b)1 $t = 1\text{ sec.}$

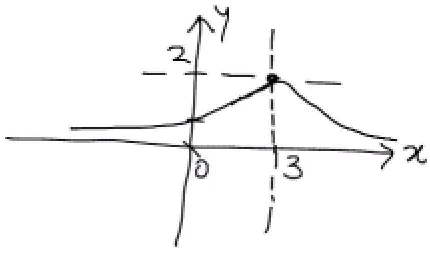
$$y = \frac{2}{(x-3t)^2+1}$$

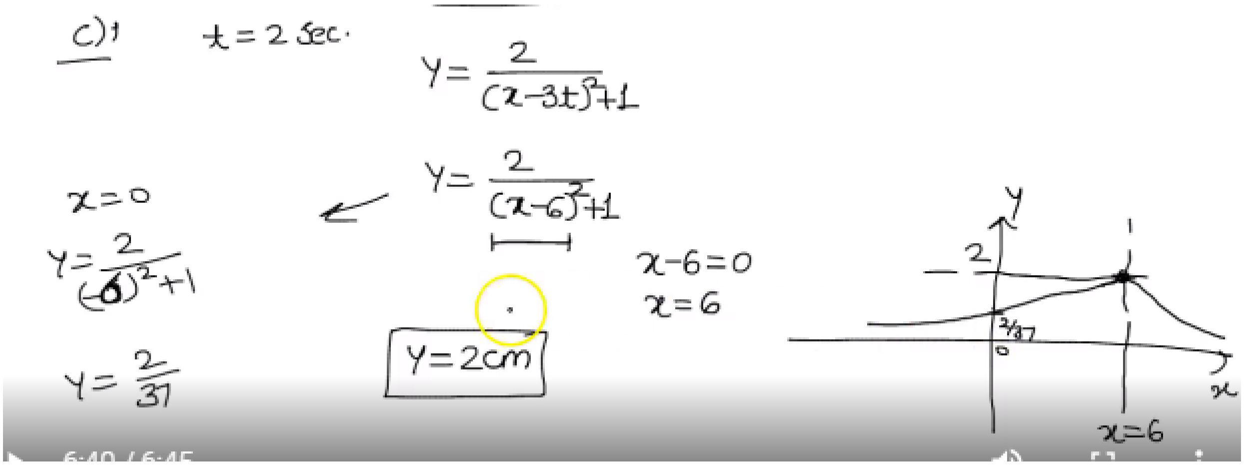
$$y = \frac{2}{(x-3)^2+1}$$

$$x-3=0$$

$$\boxed{x=3}$$

$$\boxed{y=2\text{cm}}$$




c)
t = 2 sec.
$y = \frac{2}{(x-3t)^2+1}$
$x=0$
$y = \frac{2}{(-6)^2+1}$
$y = \frac{2}{37}$
$y = \frac{2}{(x-6)^2+1}$
$x-6=0$
$x=6$
$y = 2cm$
y
2
2/37
0
x
x=6
6:40 / 6:45

GOOD LUCK