Ministry of Higher Education & Scientific Research
University of Technology
Laser & Optoelectronics Eng. Department
Branch: Optoelectronics Eng.
Class: 4th Year
Subject: RS & Image Processing

Final Examination
Time: 3 hours
Date: 7 / 6 / 2016
Examiner: Asst. Prof. Dr. Mehdi Munshid
Code: OPE 4305
Academic Year: 2015-2016

Attempt only five Questions
Note: All questions have same weight (12 marks)

Q1: (a) Classify the Remote sensing systems into two main sensors, and then state each one?

(b) What is the advantage of active sensor over the passive sensor?
(c) Show an example of two known active sensors?

(d) Electromagnetic energy may be detected either photographically or electronically. What is the photographic process?

(e) How do you can distinguish between the terms **images** and **photographs** in remote sensing?

Q2: (a) There are three types of platforms used for sensing. What are they?

(b) What is the orbit of satellite?

(c) What is **geostationary orbits**?

(d) What are near-polar orbits?

(e) What is local sun time?

(f) What are the **ascending and descending passes**?

(g) What is swath?

Q3: (a) What is the IFOV? What is the resolution cell? What is the spatial resolution?

(b) What is the course or low resolution image? What is fine or high resolution image?

(c) What is the spectral resolution?

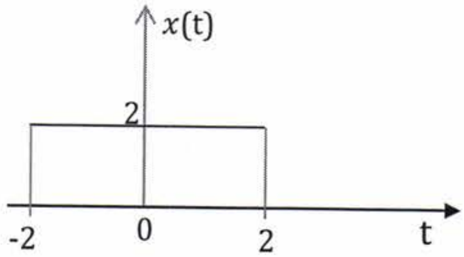
(d) What is **multi-spectral sensors**? What is **hyperspectral sensors** ?

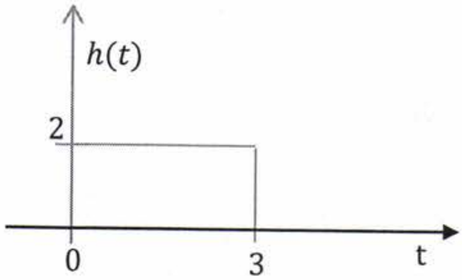
(e) What is the radiometric resolution?

(f) A scanning system used to collect data over a variety of different wavelength ranges is called a **multispectral scanner (MSS).** There are two main modes or methods of scanning employed to acquire multispectral image data - **across-track scanning**, and **along-track scanning**. State the scanning process of only one mode of them?

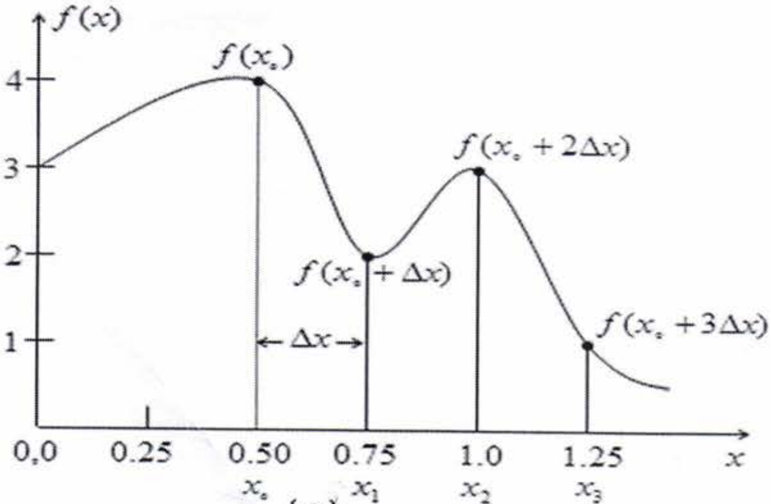
(g) What are the advantages of along-track scanners with linear arrays over across-track mirror scanners? Then show the advantages of these two types over photographic systems?

Q4: Draw the output waveform produced from correlating the following two continuous signals?

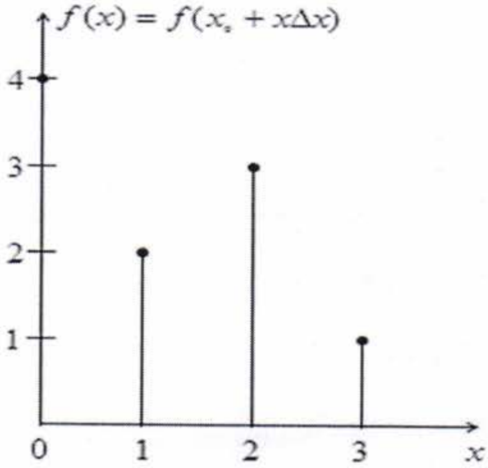




Q5: If the function shown in (a) is sampled at argument values $x_{\circ} = 0.50$, $x_1 = 0.75$, $x_2 = 1.00$, and $x_3 = 1.25$ to obtain the sequence $f(x) = \{4, 2, 3, 1\}$, and if the argument is redefined to obtain the discrete function shown in (b). Find Discrete Fourier Transform (DFT) of the sampled function? Then find its Fourier spectrum?

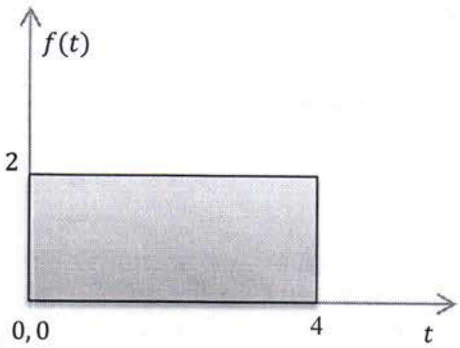


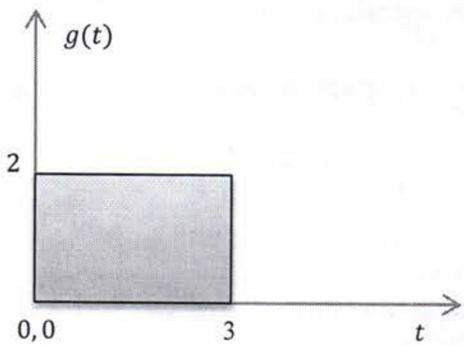
(a)



(b)

Q6: Find the convolution of the following two continuous functions? Then sketch the output waveform?





Good luck

اجوبة نموذج الأسئلة رقم-1

Q1: (a) There are two systems, passive and active sensors:

The sun provides a very convenient source of energy for remote sensing. The sun's energy is either **reflected**, as it is for visible wavelengths, or absorbed and then **re-emitted**, as it is for thermal infrared wavelengths. Remote sensing systems which measure energy that is naturally available are called **passive sensors**. Passive sensors can only be used to detect energy when the naturally occurring energy is available. For all reflected energy, this can only take place during the time when the sun is illuminating the Earth.

Active sensors, on the other hand, provide their own energy source for illumination. The sensor emits radiation which is directed toward the target to be investigated. The radiation reflected from that target is detected and measured by the sensor. Advantages for active sensors include the ability to obtain measurements anytime, regardless of the time of day or season. Active sensors can be used for examining wavelengths that are not sufficiently provided by the sun, such as microwaves, or to better control the way a target is illuminated. However, active systems require the generation of a fairly large amount of energy to adequately illuminate targets. Some examples of active sensors are a laser fluorosensor and a synthetic aperture radar (SAR).

(b)

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(1) the ability to obtain measurements anytime, regardless of the time of day or season.

(2) Active sensors can be used for examining wavelengths that are not sufficiently provided by the sun, such as microwaves, or to better control the way a target is illuminated. However, active systems require the generation of a fairly large amount of energy to adequately illuminate targets.

(c) Some examples of active sensors are a laser fluorosensor and a synthetic aperture radar (SAR).

(d) The photographic process uses chemical reactions on the surface of light-sensitive film to detect and record energy variations.

(e) An **image** refers to any pictorial representation, regardless of what wavelengths or remote sensing device has been used to detect and record the electromagnetic energy. A **photograph** refers specifically to images that have been detected as well as recorded on photographic film. Photos are normally recorded over the wavelength range from 0.3 μm to 0.9 μm - the visible and reflected infrared. Based

on these definitions, we can say that all photographs are images, but not all images are photographs. Therefore, unless we are talking specifically about an image recorded photographically, we use the term image.

Q2: (a) There three types of platforms for sensors

(1) **Ground-based sensors** are often used to record detailed information about the surface which is compared with information collected from aircraft or satellite sensors. In some cases, this can be used to better characterize the target which is being imaged by these other sensors, making it possible to better understand the information in the imagery. Sensors may be placed on a ladder, scaffolding, tall building, cherry-picker, crane, etc.

(2) on an aircraft or balloon (or some other platform within the Earth's atmosphere). **Aerial platforms** are primarily stable wing **aircraft**, although helicopters are occasionally used. Aircraft are often used to collect very detailed images and facilitate the collection of data over virtually any portion of the Earth's surface at any time.

(3) In space, remote sensing is sometimes conducted from the **space shuttle** or, more commonly, from satellites. **Satellites** are objects which revolve around another object - in this case, the Earth. For example, the moon is a natural satellite, whereas man-made satellites include those platforms launched for remote sensing, communication, and telemetry (location and navigation) purposes. Because of their orbits, satellites permit repetitive coverage of the Earth's surface on a continuing basis.

(b) The path followed by a satellite is referred to as its **orbit**. Satellite orbits are matched to the capability and objective of the sensor(s) they carry. Orbit selection can vary in terms of altitude (their height above the Earth's surface) and their orientation and rotation relative to the Earth.

(c) Satellites at very high altitudes, which view the same portion of the Earth's surface at all times have **geostationary orbits**. These geostationary satellites, at altitudes of approximately 36,000 kilometres, revolve at speeds which match the rotation of the Earth so they seem stationary, relative to the Earth's surface. This allows the satellites to observe and collect information continuously over specific areas. Weather and communications satellites commonly have these types of orbits. Due to their high altitude, some geostationary weather satellites can monitor weather and cloud patterns covering an entire hemisphere of the Earth.

(d) Many remote sensing platforms are designed to follow an orbit (basically north-south) which, in conjunction with the Earth's rotation (west-east), allows them to cover most of the Earth's surface over a certain period of time. These are **near-polar orbits**, so named for the inclination of the orbit relative to a line running between the North and South poles. Many of these satellite orbits are also **sun-synchronous** such that they cover each area of the world at a constant local time of day called **local sun time**. At any given latitude, the position of the sun in the sky as the satellite passes overhead will be the same within the same season. This ensures consistent illumination conditions when acquiring images in a specific season over successive

years, or over a particular area over a series of days. This is an important factor for monitoring changes between images or for mosaicking adjacent images together, as they do not have to be corrected for different illumination conditions.

(e) Many of these satellite orbits are also **sun-synchronous** such that they cover each area of the world at a constant local time of day called **local sun time**. At any given latitude, the position of the sun in the sky as the satellite passes overhead will be the same within the same season. This ensures consistent illumination conditions when acquiring images in a specific season over successive years, or over a particular area over a series of days. This is an important factor for monitoring changes between images or for mosaicking adjacent images together, as they do not have to be corrected for different illumination conditions.

(f) Most of the remote sensing satellite platforms today are in near-polar orbits, which means that the satellite travels northwards on one side of the Earth and then toward the southern pole on the second half of its orbit. These are called **ascending and descending passes**, respectively. If the orbit is also sun-synchronous, the ascending pass is most likely on the shadowed side of the Earth while the descending pass is on the sunlit side. Sensors recording reflected solar energy only image the surface on a descending pass, when solar illumination is available. Active sensors which provide their own illumination or passive sensors that record emitted (e.g. thermal) radiation can also image the surface on ascending passes.

(g) As a satellite revolves around the Earth, the sensor "sees" a certain portion of the Earth's surface. The area imaged on the surface, is referred to as the **swath**. Imaging swaths for spaceborne sensors generally vary between tens and hundreds of kilometres wide.

Q3: (a) Spatial resolution of passive sensors (we will look at the special case of active microwave sensors later) depends primarily on their **Instantaneous Field of View (IFOV)**. The IFOV is the angular cone of visibility of the sensor (A) and determines the area on the Earth's surface which is "seen" from a given altitude at one particular moment in time (B). The size of the area viewed is determined by multiplying the IFOV by the distance from the ground to the sensor (C). This area on the ground is called the **resolution cell** and determines a sensor's **maximum spatial resolution**.

(b) Images where only large features are visible are said to have **coarse or low resolution.** In **fine or high resolution** images, small objects can be detected. Military sensors for example, are designed to view as much detail as possible, and therefore have very fine resolution.

(c) **Spectral resolution** describes the ability of a sensor to define fine wavelength intervals. The finer the spectral resolution, the narrower the wavelength range for a particular channel or band.

(d) Many remote sensing systems record energy over several separate wavelength ranges at various spectral resolutions. These are referred to as **multi-spectral sensors** and will be described in some detail in following sections. Advanced multi-spectral sensors called **hyperspectral** sensors, detect hundreds of very narrow spectral bands throughout the visible, near-infrared, and mid-infrared portions of the electromagnetic

spectrum. Their very high spectral resolution facilitates fine discrimination between different targets based on their spectral response in each of the narrow bands.

(e) Every time an image is acquired on film or by a sensor, its sensitivity to the magnitude of the electromagnetic energy determines the **radiometric resolution**. The radiometric resolution of an imaging system describes its ability to discriminate very slight differences in energy. The finer the radiometric resolution of a sensor, the more sensitive it is to detecting small differences in reflected or emitted energy.

(f) **Across-track scanners** scan the Earth in a series of lines. The lines are oriented perpendicular to the direction of motion of the sensor platform (i.e. across the swath). Each line is scanned from one side of the sensor to the other, using a **rotating mirror (A)**. As the platform moves forward over the Earth, successive scans build up a two-dimensional image of the Earth´s surface. The incoming reflected or emitted radiation is separated into several spectral components that are detected independently. The UV, visible, near-infrared, and thermal radiation are dispersed into their constituent wavelengths. A bank of internal **detectors (B)**, each sensitive to a specific range of wavelengths, detects and measures the energy for each spectral band and then, as an electrical signal, they are converted to digital data and recorded for subsequent computer processing.

Along-track scanners also use the forward motion of the platform to record successive scan lines and build up a two-dimensional image, perpendicular to the flight direction. However, instead of a scanning mirror, they use a linear array of detectors (A) located at the focal plane of the image (B) formed by lens systems (C), which are "pushed" along in the flight track direction (i.e. along track). These systems are also referred to as **pushbroom scanners**, as the motion of the detector array is analogous to the bristles of a broom being pushed along a floor. Each individual detector measures the energy for a single ground resolution cell (D) and thus the size and IFOV of the detectors determines the spatial resolution of the system. A separate linear array is required to measure each spectral band or channel. For each scan line, the energy detected by each detector of each linear array is sampled electronically and digitally recorded.

(g) Along-track scanners with linear arrays have several advantages over across-track mirror scanners. The array of detectors combined with the pushbroom motion allows each detector to "see" and measure the energy from each ground resolution cell for a longer period of time (dwell time). This allows more energy to be detected and improves the radiometric resolution. The increased dwell time also facilitates smaller IFOVs and narrower bandwidths for each detector. Thus, finer spatial and spectral resolution can be achieved without impacting radiometric resolution. Because detectors are usually solid-state microelectronic devices, they are generally smaller, lighter, require less power, and are more reliable and last longer because they have no moving parts. On the other hand, cross-calibrating thousands of detectors to achieve uniform sensitivity across the array is necessary and complicated.

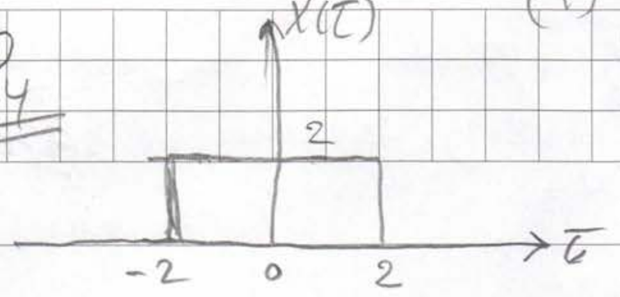
Regardless of whether the scanning system used is either of these two types, it has several advantages over photographic systems. The spectral range of photographic systems is restricted to the visible and near-infrared regions while MSS systems can extend this range into the thermal infrared. They are also capable of much higher

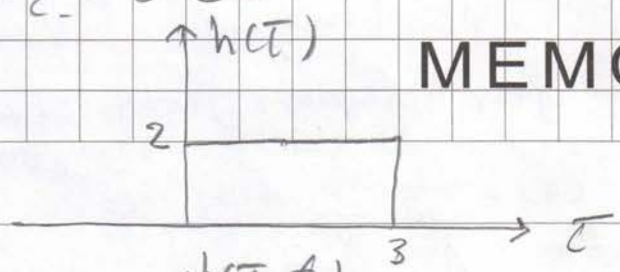
spectral resolution than photographic systems. Multi-band or multispectral photographic systems use separate lens systems to acquire each spectral band. This may cause problems in ensuring that the different bands are comparable both spatially and radiometrically and with registration of the multiple images. MSS systems acquire all spectral bands simultaneously through the same optical system to alleviate these problems. Photographic systems record the energy detected by means of a photochemical process which is difficult to measure and to make consistent. Because MSS data are recorded electronically, it is easier to determine the specific amount of energy measured, and they can record over a greater range of values in a digital format. Photographic systems require a continuous supply of film and processing on the ground after the photos have been taken. The digital recording in MSS systems facilitates transmission of data to receiving stations on the ground and immediate processing of data in a computer environment.

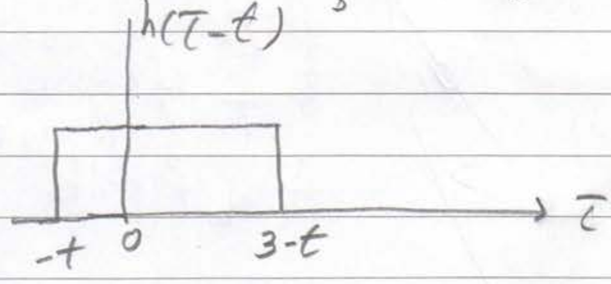
حلول نموذج رقم (1)

MEMO

Q4







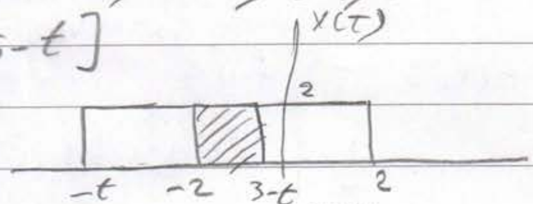
$y(t) = \int x(\tau)\, h(\tau - t)\, d\tau$

$= \int 2 * 2\, d\tau = 4\tau$

$y(t) = 0$ for $[3-t \leq -2] * -1 = t-3 \geq 2 \Rightarrow t \geq 5$

for $-2 \leq 3-t \leq 0 \Rightarrow 2 \geq t-3 \geq 0 \Rightarrow 5 \geq t \geq 3$

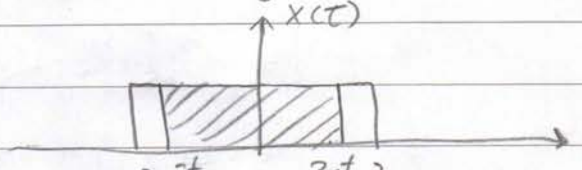
$y(t) = 4[\tau]_{-2}^{3-t} = 4[3-t+2] = 4[5-t]$



$y(t) = 0$ for $t = 5$

$= 4$ for $t = 4$

$= 8$ for $t = 3$



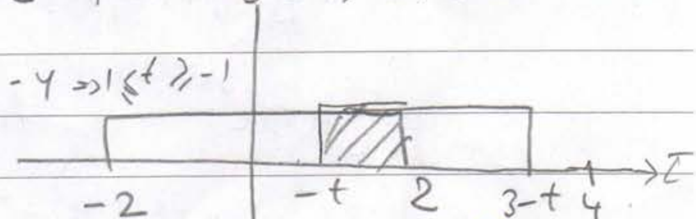
for $[0 \leq 3-t \leq 2] * -1 \Rightarrow$

$0 \geq t-3 \geq -2 \Rightarrow 3 \geq t \geq 1$

$y(t) = 4[\tau]_{-t}^{3-t} = 4[3-\cancel{t}+\cancel{t}] = 12$ for $t = 1, 2$

for $2 \leq 3-t \leq 4 \Rightarrow -2 \geq t-3 \geq -4 \Rightarrow 1 \leq t \geq -1$

$y(t) = 4[\tau]_{-t}^{2} = 4[2+t]$

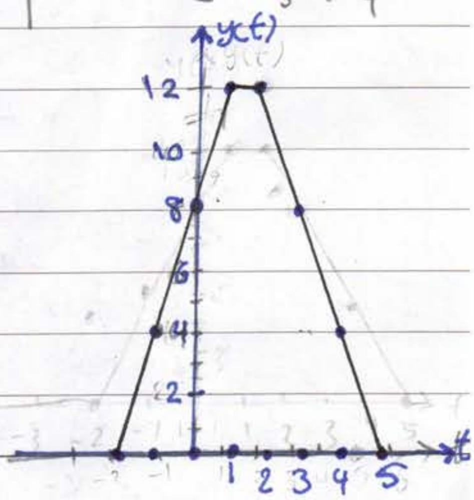


$= 8$ for $t = 0$

$= 4$ for $t = -1$

$= 12$ for $t = 1$

$y(t) = 0$ for $-t \geq 2 \Rightarrow \boxed{t \leq -2}$



2015 (1) 2016

Q_5 Applicating the following Equation to the following four samples, yields the following sequence of steps.

$$F(u) = \frac{1}{N}\sum_{x=0}^{N-1} f(x)\, e^{-j2\pi ux/N} \qquad N=4 \Rightarrow N-1=3$$

$$F(0) = \frac{1}{4}\sum_{x=0}^{3} f(x)\, e^{-j2\pi ux/N}$$

$$= \frac{1}{4}\left[f(0)e^{-j2\pi(0)(0)/4} + f(1)e^{-j2\pi(0)(1)/4} + f_2 e^{-j2\pi(0)(2)/4} + f(3)e^{-j2\pi(0)(3)/4}\right]$$

$$= \frac{1}{4}\left[f(0)+f(1)+f(2)+f(3)\right]$$

$$= \frac{1}{4}\left[4+2+3+1\right] = \frac{10}{4} = \frac{5}{2}$$

$$F(1) = \frac{1}{4}\left[f(0)e^{-j2\pi(1)(0)/4} + f(1)e^{-j2\pi(1)(1)/4} + f(2)e^{-j2\pi(1)(2)/4} + f(3)e^{-j2\pi(1)(3)/4}\right]$$

$$= \frac{1}{4}\left[f(0)e^{0} + f(1)e^{-j\frac{\pi}{2}} + f(2)e^{-j\pi} + f(3)e^{-j3\pi/2}\right]$$

$$= \frac{1}{4}\left[4 + 2\left(\underbrace{\cos\tfrac{\pi}{2}}_{=0} - j\underbrace{\sin\tfrac{\pi}{2}}_{=1}\right) + 3\left(\underbrace{\cos\pi}_{=-1} - j\underbrace{\sin\pi}_{=0}\right) + 1\left(\underbrace{\cos\tfrac{3\pi}{2}}_{=0} - j\underbrace{\sin\tfrac{3\pi}{2}}_{=-1}\right)\right]$$

$$= \frac{1}{4}\left[4 + 2(-j) + 3(-1) + 1(-j(-1))\right]$$

$$= \frac{1}{4}\left[4 - 2j - 3 + j\right] = \frac{1}{4}\left[1-j\right]$$

$$\therefore |F(1)| = \left[\left(\frac{1}{4}\right)^2 + \left(\frac{-j}{4}\right)^2\right]^{1/2} = \left[\frac{1}{16}+\frac{1}{16}\right]^{1/2} = \left[\frac{2}{16}\right]^{1/2} = \frac{\sqrt{2}}{4}$$

$$F(2) = \frac{1}{4}\left[f(0)e^{-j2\pi(2)(0)/4} + f(1)e^{-j2\pi(2)(1)/4} + f(2)e^{-j2\pi(2)(2)/4} + f(3)e^{-j2\pi(2)(3)/4}\right]$$

$$= \frac{1}{4}\left[f(0) + f(1)e^{-j\pi} + f(2)e^{-j2\pi} + f(3)e^{-j3\pi}\right]$$

$$= \frac{1}{4}\left[4 + 2(\cos\pi - j\sin\pi) + 3(\cos 2\pi - j\sin 2\pi) + 1(\cos 3\pi - j\sin 3\pi)\right]$$

$$= \frac{1}{4}\left[4 + 2(-1) + 3(1) + 1(-1)\right] = \frac{1}{4}[4] = 1 \Rightarrow |F(2)| = 1$$

$$F(3) = \frac{1}{4}\left[f(0) + f(1)e^{-j2\pi(3)(1)/4} + f(2)e^{-j2\pi(3)(2)/4} + f(3)e^{-j2\pi(3)(3)/4}\right]$$

$$= \frac{1}{4}\left[4 + 2(-j)(-1) + 3(-1) + 1(-j)(1)\right]$$

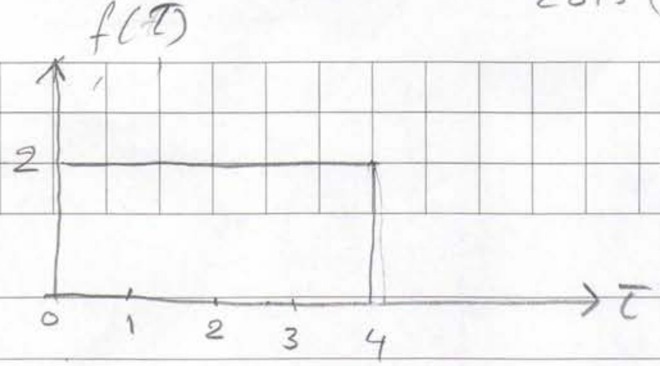
$$= \frac{1}{4}\left[4 + 2j - 3 - j\right] = \frac{1}{4}\left[1+j\right]$$

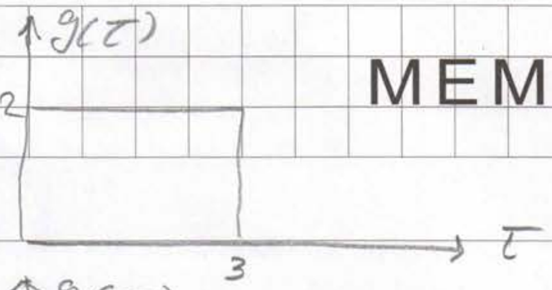
$$|F(3)| = \left(\frac{1}{16}+\frac{1}{16}\right)^{1/2} = \left(\frac{2}{16}\right)^{1/2} = \frac{\sqrt{2}}{4} \Rightarrow |F(u)|_{total} = |F(0)| + |F(1)| + |F(2)| + |F(3)| = \frac{5}{2} + \frac{\sqrt{2}}{4} + 1 + \frac{\sqrt{2}}{4}$$

2016 حلول نموذج (1) 2015

MEMO

Q6

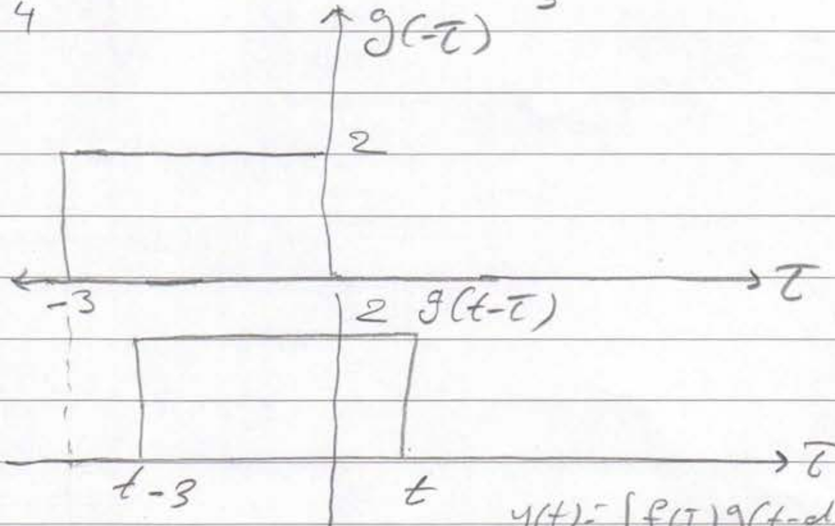




$y(t) = \int f(\tau)\, g(t-\tau)\, d\tau$

$= \int 2 * 2\, d\tau$

$= 4\tau$



$y(t) = 0$ for $t \leq 0$

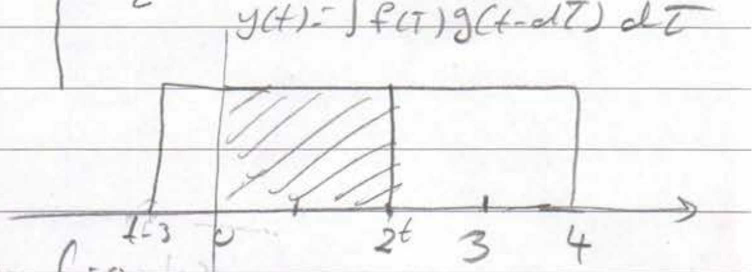
for $0 \leq t \leq 2$

$y(t) = 4\left[\tau\right]_0^t = 4[t]$

$= 0$ for $t = 0$

$= 4$ for $t = 1$

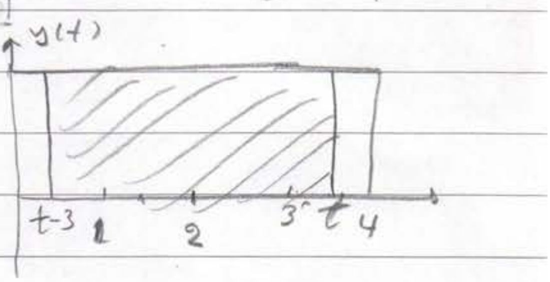
$= 8$ for $t = 2$



for $3 \leq t \leq 4$

$y(t) = 4\left[\tau\right]_{t-3}^{t} = 4[\cancel{t} - \cancel{t} + 3]$

$= 12$ for $t = 3, 4$



for $6 \leq t \leq 7$

$y(t) = 4\left[\tau\right]_{t-3}^{4} = 4[4 - t + 3]$

$= 4[7 - t]$

$= 0$ for $t = 7$

$= 4$ for $t = 6$

$= 8$ for $t = 5$