University of Technology
Department of Laser&Optoelectronics Engineering.
Final Examination 2011-2012

Subject: Image processing and RS — ***Class:*** *4th year*
Division: Optoelectronics Eng. — ***Time:*** *3 hours*
Examiner: Dr. Mehdi Munshid Shellal — ***Date:*** *28 5/2012*

Answer only five questions

All questions have same weights (12 marks)

Q1: (a)What is remote sensing?

(b) State in sequence the seven elements involved in the process of remote sensing ?

(c) What are the main regions of the electromagnetic spectrum which are useful for remote sensing?

Q2: Particles and gases in the atmosphere can affect the incoming light and radiation. These effects are caused by the mechanisms of **scattering** and **absorption.** **Scattering** occurs when particles or large gas molecules present in the atmosphere interact with and cause the electromagnetic radiation to be redirected from its original path.

(a) What are the main factors which the scattering depends on to take place?

(b) There are three (3) types of scattering which take place. What are they? Explain each One?

(C) What are the main atmospheric constituents which absorb the incoming radiation?

(d) What are the atmospheric windows?

Q3: Radiation that is not absorbed or scattered in the atmosphere can reach and interact with the Earth's surface.

(a) What are the main three forms of interaction that can take place when energy strikes, or is **incident (I)** upon the Earth's surface.

(b) The total incident energy will interact with the surface in one or more of these three ways. What are the parameters which the proportions of each will depend on ?

(c) In remote sensing, we are most interested in measuring the radiation reflected from targets. What are the two types of reflection, which represent the two extreme ends of the way in which energy is reflected from a target?

"اقلب الصفحة رجاءا" ، أ.د. مهدي

(d) Which type of reflection we obtain for the following conditions?

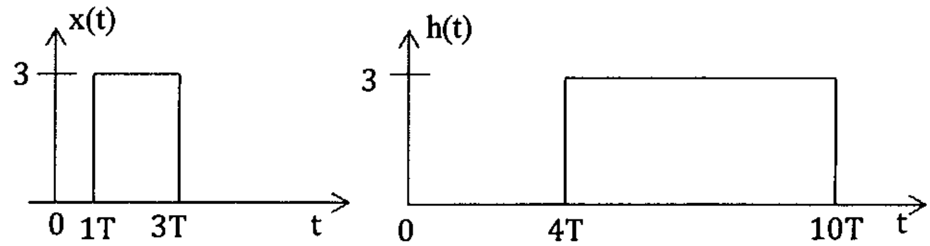
(1) when a surface feature is smooth in comparison to the wavelength of the incoming radiation and

(2) when the surface is rough.

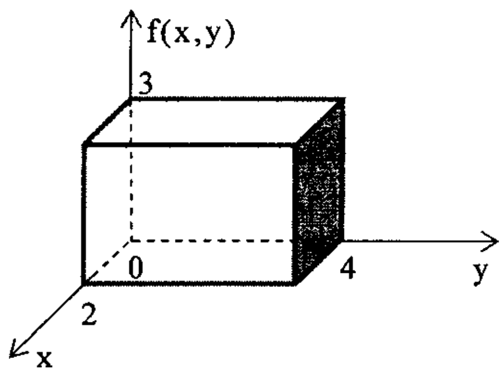
(e) Why Leaves appear "greenest" to us in the summer but appear red or yellow in autumn?

(f) Why water typically looks blue or blue-green?

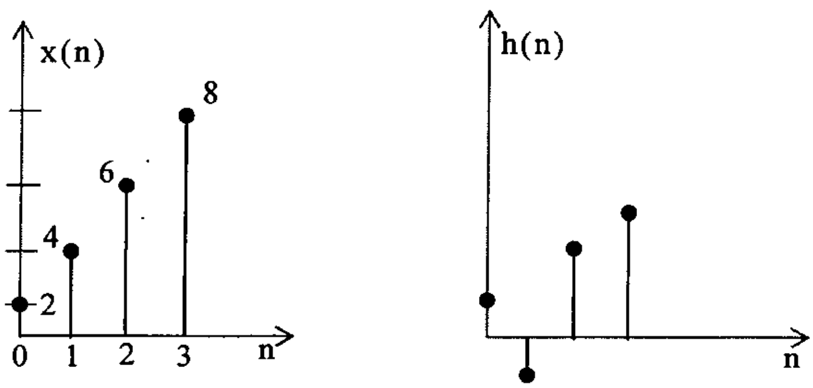
Q4: Find the convolution of the following two signals. Then draw the waveform of the output signal?



Q5:Consider the function shown below. Find its Fourier transform, its Fourier spectrum. Then find its power spectrum (spectral density) ?



Q6: Find the outputsequence of pulses resulted from the cross correlation of the following two sequences of pulses? X(n)={2,4,6,8}, h(n)={2, -2, 4,5}



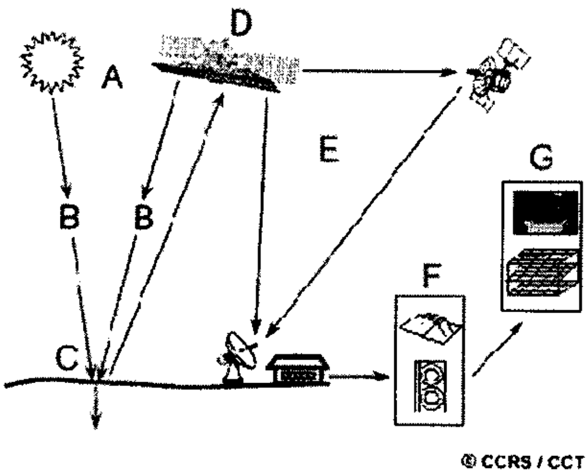
Good luck

حلول نموذج ١ أسئلة نهائية

Q1:

(a): "Remote sensing is the science (and to some extent, art) of acquiring information about the Earth's surface without actually being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information."

(b) In much of remote sensing, **the process** involves an interaction between incident radiation and the targets of interest. This is exemplified by the use of imaging systems where the following seven elements are involved. Note, however that remote sensing also involves the sensing of emitted energy and the use of non-imaging sensors.



1. Energy Source or Illumination (A) - the first requirement for remote sensing is to have an energy source which illuminates or provides electromagnetic energy to the target of interest.

2. Radiation and the Atmosphere (B) - as the energy travels from its source to the target, it will come in contact with and interact with the atmosphere it passes through. This interaction may take place a second time as the energy travels from the target to the sensor.

3. Interaction with the Target (C) - once the energy makes its way to the target through the atmosphere, it interacts with the target depending on the properties of both the target and the radiation.

4. Recording of Energy by the Sensor (D) - after the energy has been scattered by, or emitted from the target, we require a sensor (remote - not in contact with the target) to collect and record the electromagnetic radiation.

5. Transmission, Reception, and Processing (E) - the energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data are processed into an image (hardcopy and/or digital).

6. Interpretation and Analysis (F) - the processed image is interpreted, visually and/or digitally or electronically, to extract information about the target which was illuminated.

7. Application (G) - the final element of the remote sensing process is achieved when we apply the information we have been able to extract from the imagery about the target in order to better understand it, reveal some new information, or assist in solving a particular problem.

(c)

(1) The **ultraviolet or UV** portion of the spectrum has the shortest wavelengths which are practical for remote sensing. This radiation is just beyond the violet portion of the visible wavelengths, hence its name. Some Earth surface materials, primarily rocks and minerals, fluoresce or emit visible light when illuminated by UV radiation.

(2) The **visible spectrum**. The visible wavelengths cover a range from approximately 0.4 to 0.7 μm. The longest visible wavelength is red and the shortest is violet. Common wavelengths of what we perceive as particular colours from the visible portion of the spectrum are listed below. It is important to note that this is the only portion of the spectrum we can associate with the concept of **colours**.

Violet: 0.4 - 0.446 μm, **Blue:** 0.446 - 0.500 μm, **Green:** 0.500 - 0.578 μm,

Yellow: 0.578 - 0.592 μm, **Orange:** 0.592 - 0.620 μm, **Red:** 0.620 - 0.7 μm

(3) The next portion of the spectrum of interest is the **infrared (IR) region** which covers the wavelength range from approximately 0.7 μm to 100 μm - more than 100 times as wide as the visible portion! The infrared region can be divided into two categories based on their radiation properties - the **reflected IR**, and the emitted or **thermal IR**. Radiation in the reflected IR region is used for remote sensing purposes in ways very similar to radiation in the visible portion. The reflected IR covers wavelengths from approximately 0.7 μm to 3.0 μm. The thermal IR region is quite different than the visible and reflected IR portions, as this energy is essentially the radiation that is emitted from the Earth's surface in the form of heat. The thermal IR covers wavelengths from approximately 3.0 μm to 100 μm.

(4) The portion of the spectrum of more recent interest to remote sensing is the **microwave region** from about 1 mm to 1 m. This covers the longest wavelengths used for remote sensing. The shorter wavelengths have properties similar to the thermal infrared region while the longer wavelengths approach the wavelengths used for radio broadcasts.

Q2: (a) several factors including

(1) The wavelength of the radiation,

(2) The abundance of particles or gases, and

(3) The distance the radiation travels through the atmosphere.

(b)

$P \ll \lambda$

(1) Rayleigh scattering occurs when particles are very small compared to the wavelength of the radiation. These could be particles such as small specks of dust or nitrogen and oxygen molecules. Rayleigh scattering causes shorter wavelengths of energy to be scattered much more than longer wavelengths. Rayleigh scattering is the dominant scattering mechanism in the upper atmosphere. The fact that the sky appears "blue" during the day is because of this phenomenon. As sunlight passes through the atmosphere, the shorter wavelengths (i.e. blue) of the visible spectrum are scattered more than the other (longer) visible wavelengths. At **sunrise and sunset** the light has to travel farther through the atmosphere than at midday and the scattering of the shorter wavelengths is more complete; this leaves a greater proportion of the longer wavelengths to penetrate the atmosphere.

$P \equiv \lambda$

(2) Mie scattering occurs when the particles are just about the same size as the wavelength of the radiation. Dust, pollen, smoke and water vapour are common causes of Mie scattering which tends to affect longer wavelengths than those affected by Rayleigh scattering. Mie scattering occurs mostly in the lower portions of the atmosphere where larger particles are more abundant, and dominates when cloud conditions are overcast.

$P \gg \lambda$

(3) The final scattering mechanism of importance is called **nonselective scattering**. This occurs when the particles are much larger than the wavelength of the radiation. Water droplets and large dust particles can cause this type of scattering. Nonselective scattering gets its name from the fact that all wavelengths are scattered about equally. This type of scattering causes fog and clouds to appear white to our eyes because blue, green, and red light are all scattered in approximately equal quantities (blue+green+red light = white light).

(c)

(1) Ozone serves to absorb the harmful (to most living things) ultraviolet radiation from the sun. Without this protective layer in the atmosphere our skin would burn when exposed to sunlight.

(2) **carbon dioxide** referred to as a greenhouse gas. This is because it tends to absorb radiation strongly in the far infrared portion of the spectrum - that area associated with thermal heating - which serves to trap this heat inside the atmosphere. Water vapour in the atmosphere absorbs much of the incoming longwave infrared and shortwave microwave radiation (between 22μm and 1m).

(3) The presence of **water vapour** in the lower atmosphere varies greatly from location to location and at different times of the year. For example, the air mass above a desert would have very little water vapour to absorb energy, while the tropics would have high concentrations of water vapour (i.e. high humidity).

(d)

Those areas of the spectrum which are not severely influenced by atmospheric absorption and thus, are useful to remote sensors, are called **atmospheric windows.** By comparing the characteristics of the two most common energy/radiation sources (the sun and the earth) with the atmospheric windows available to us, we can define those wavelengths that we can use **most effectively** for remote sensing. The visible portion of the spectrum, to which our eyes are most sensitive, corresponds to both an atmospheric window and the peak energy level of the sun. Note also that heat energy emitted by the Earth corresponds to a window around 10 μm in the thermal IR portion of the spectrum, while the large window at wavelengths beyond 1 mm is associated with the microwave region.

Q3:

(a) There are three (3) forms of interaction that can take place These are: **absorption (A); transmission (T)**; and **reflection (R)**.

(b)

(1) The wavelength of the energy and

(2) The material and

(3) Condition of the feature

(c) (1) specular reflection and

(2) diffuse reflection.

(d)

(1)We get **specular** or mirror-like reflection where all (or almost all) of the energy is directed away from the surface in a single direction.

(2) **Diffuse** reflection occurs when the surface is rough and the energy is reflected almost uniformly in all directions.

Most earth surface features lie somewhere between perfectly specular or perfectly diffuse reflectors. Whether a particular target reflects specularly or diffusely, or somewhere in between, depends on the surface roughness of the feature in comparison to the wavelength of the incoming radiation. If the wavelengths are much smaller than the surface variations or the particle sizes that make up the surface, diffuse reflection will dominate. For example, fine-grained sand would appear fairly smooth to long wavelength microwaves but would appear quite rough to the visible wavelengths.

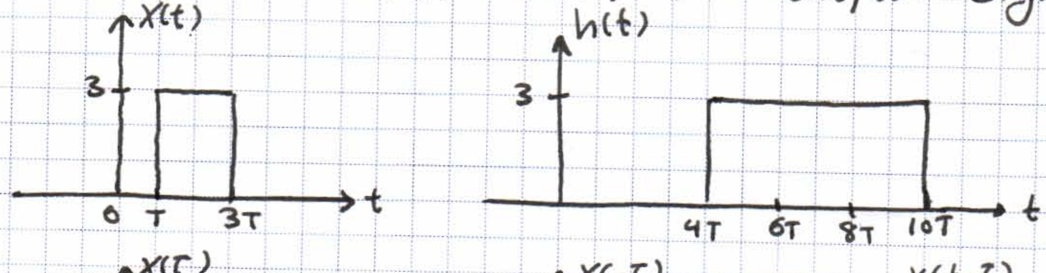
(e) **Leaves**: A chemical compound in leaves called chlorophyll strongly absorbs radiation in the red and blue wavelengths but reflects green wavelengths. Leaves appear "greenest" to us in the summer, when chlorophyll content is at its maximum. In autumn, there is less chlorophyll in the leaves, so there is less absorption and proportionately more reflection of the red wavelengths, making the leaves appear red or yellow (yellow is a combination of red and green wavelengths). The internal structure of healthy leaves act as excellent diffuse reflectors of near-infrared wavelengths. If our eyes were sensitive to near-infrared, trees would appear extremely bright to us at these wavelengths. In fact, measuring and monitoring the near-IR reflectance is one way that scientists can determine how healthy (or unhealthy) vegetation may be.

(f) Why water typically looks blue or blue-green?

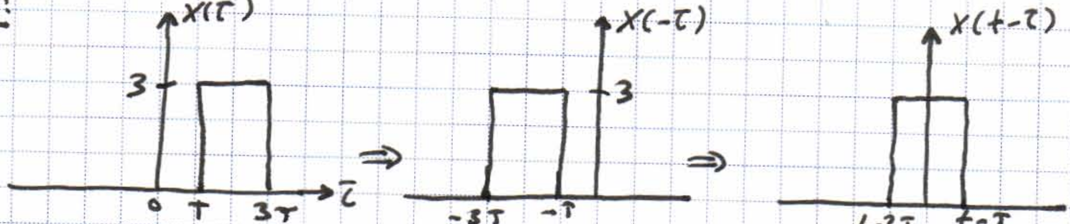
Because the longer wavelength visible and near infrared radiation is absorbed more by water than shorter visible wavelengths. Thus water typically looks blue or blue-green due to stronger reflectance at these shorter wavelengths, and darker if viewed at red or near infrared wavelengths. If there is suspended sediment present in the upper layers of the water body, then this will allow better reflectivity and a brighter appearance of the water. The apparent colour of the water will show a slight shift to longer wavelengths. Suspended sediment (S) can be easily confused with shallow (but clear) water, since these two phenomena appear very similar. Chlorophyll in algae absorbs more of the blue wavelengths and reflects the green, making the water appear more green in colour when algae is present. The topography of the water surface (rough, smooth, floating materials, etc.) can also lead to complications for water-related interpretation due to potential problems of specular reflection and other influences on colour and brightness

Erbil Rotana

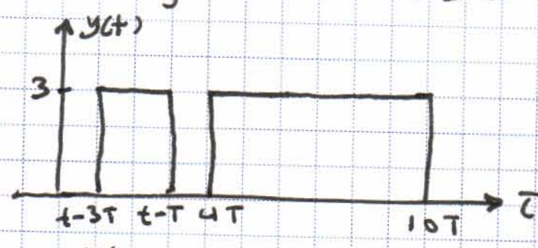
Q4 Find the Convolution of the following two signals, then draw the waveform of the output Signal



Solution:

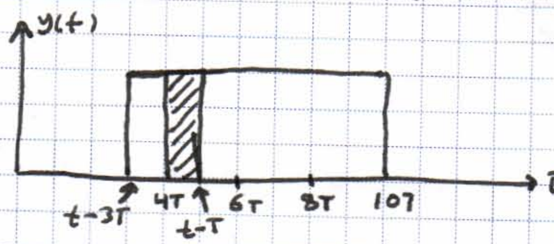


$y(t) = x(t) \otimes h(t) = \int x(\tau)\, h(t-\tau)\, d\tau = \int 3 * 3\, d\tau = 9\tau$



* for $t-T \leq 4T \Rightarrow t \leq 5T$

$\Rightarrow y(t) = 0$



* for $4T \leq t-T \leq 6T$

$5T \leq t \leq 7T$

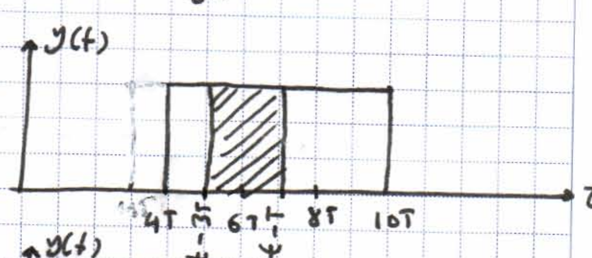
$y(t) = 9\left[\tau\right]_{4T}^{t-T} = 9\left[t-T-4T\right]$

$= 9\left[t-5T\right]$

$= 0$ for $t = 5T$

$= 9T$ for $t = 6T$

$= 18T$ for $t = 7T$

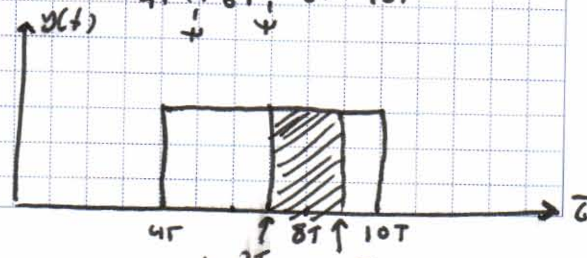


* for $6T \leq t-T \leq 8T$

$7T \leq t \leq 9T$

$\Rightarrow y(t) = 9\left[\tau\right]_{t-3T}^{t-T} = 9\left[t-T-t+3T\right]$

$= 9T$



* for $8T \leq t-T \leq 10T$

$9T \leq t \leq 11T$

$y(t) = 9\left[\tau\right]_{t-3T} = 9\left[t-T-t+3T\right]$

$= 18T$

شارع گولان، كردستان، العراق، هاتف: ٥٥٥٥ ٢١٠ ٦٦ (٠) ٩٦٤+ فاكس: ٥٥٥٦ ٢١٠ ٦٦ (٠) ٩٦٤+
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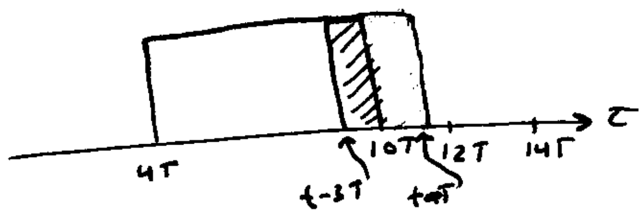
rotana.com

* for $10T \leq t-T \leq 12T$

$11T \leq t \leq 13T$



$$\Rightarrow y(t) = 9\left[\tau\right]_{t-3T}^{10T}$$

$= 9[10T - t + 3T]$

$= 9[13T - t]$

$= 18T$ for $t = 11T$

$= 9T$ for $t = 12T$

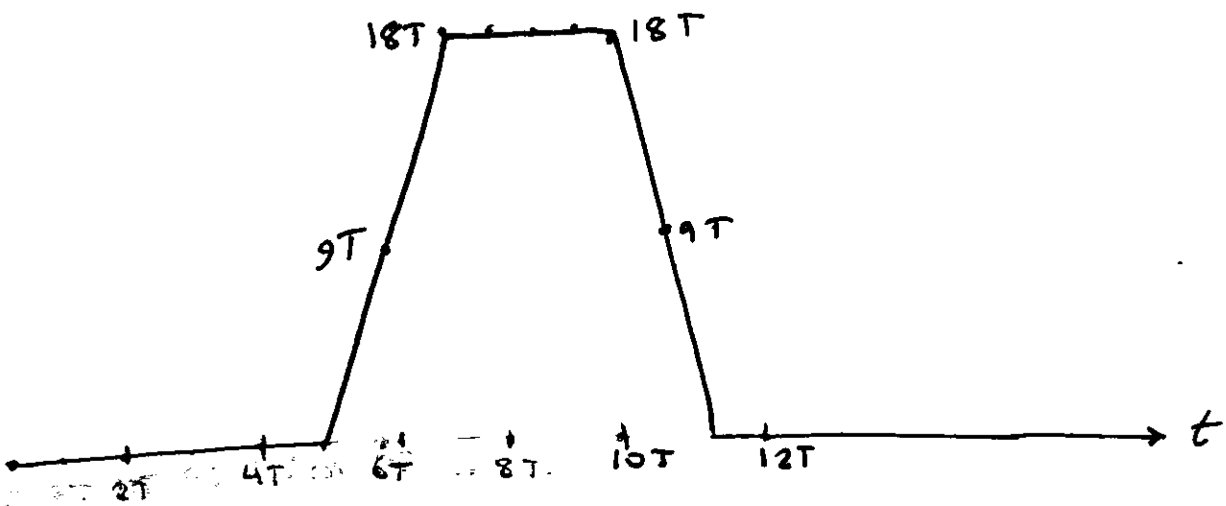
$= 0$ for $t = 13T$

* for $12T \leq t-T \leq 14T$

$13T \leq t \leq 15T$

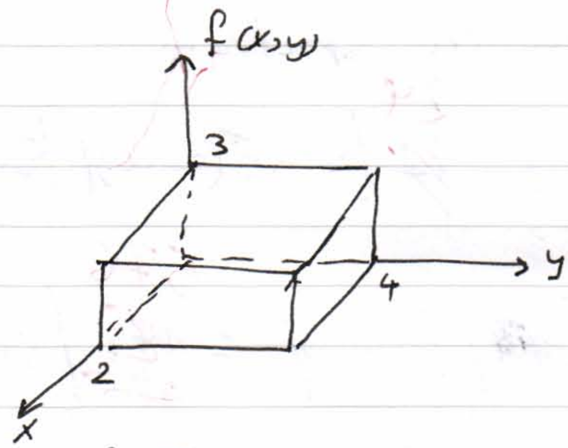
$y(t) = 0$

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



(1)2.3.5

Q5



$$F(u,v) = \iint_{-\infty}^{\infty} f(x,y)\, e^{-j2\pi(ux+vy)}\, dx\,dy$$

$$= \int_0^2\int_0^3 f(x,y)\, e^{-j2\pi(ux+vy)}\, dx\,dy$$

$$= 3\int_0^2 e^{-j2\pi ux}\, dx \int_0^4 e^{-j2\pi vy}\, dy$$

$$= 3\,\frac{1}{-j2\pi u}\Big[e^{-j2\pi ux}\Big]_0^2 \frac{1}{-j2\pi v}\Big[e^{-j2\pi vy}\Big]_0^4$$

$$= \frac{3}{-j2\pi u}\Big[e^{-j2\pi u2} - 1\Big] \frac{1}{-j2\pi v}\Big[e^{-j2\pi v(4)} - 1\Big]$$

$$= \frac{3}{-j2\pi u}\Big[e^{-j\pi u2} - e^{j\pi u2}\Big] e^{-j\pi u2}\, \frac{1}{-j2\pi v}\Big[e^{-j\pi v4} - e^{j\pi v4}\Big] e^{-j\pi v4}$$

$$= \frac{3}{j2\pi u}\Big[e^{j\pi u2} - e^{-j\pi u2}\Big] e^{-j\pi u2}\, \frac{1}{j2\pi v}\Big[e^{j\pi v4} - e^{-j\pi v4}\Big] e^{-j\pi v4}$$

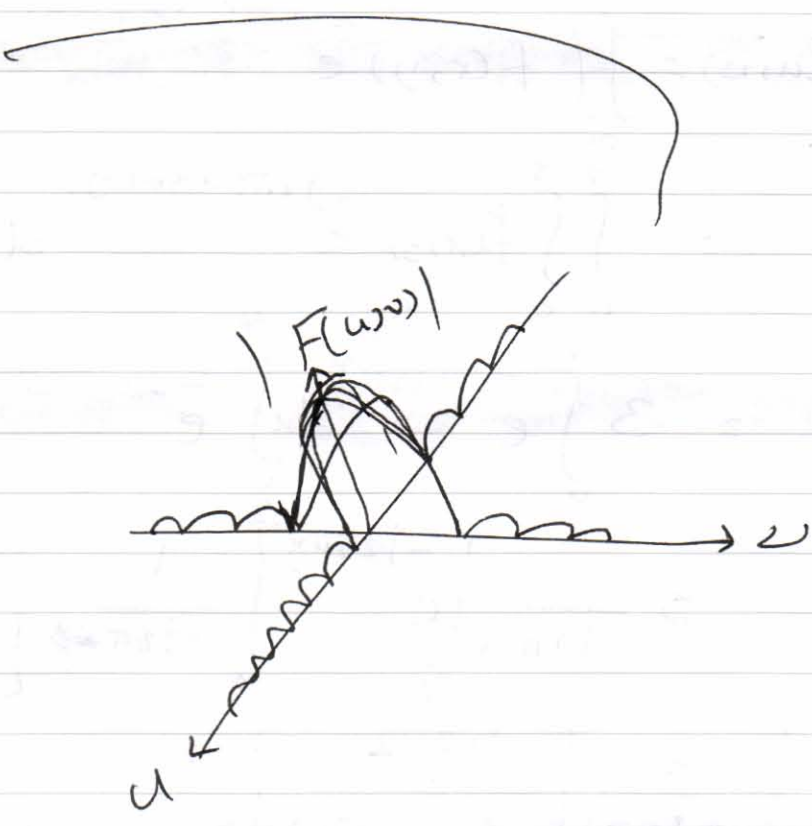
$$= \frac{3}{\pi u} * \frac{2}{2} \mathrm{Sin}(\pi u2)\, e^{-j\pi u2}\, \frac{1}{\pi v} * \frac{4}{4} \mathrm{Sin}(\pi v4)\, e^{-j\pi v4}$$

$$= \sout{12}\ 24\ \mathrm{Sinc}(2\pi u)\, e^{-j2\pi u}\, \mathrm{Sinc}(4\pi v)\, e^{-j4\pi v}$$

∴ Fourier spectrum is

$$|F(u,v)| = \cancel{12}\ 24 \, |\text{sinc}(2\pi u)| \, |\text{sinc}(4\pi v)|$$

$$P(u,v) = |F(u,v)|^2 = \cancel{144}\ 576 \, |\text{sinc}(2\pi u)|^2 \, |\text{sinc}(4\pi v)|^2$$



Q_6 نموذج (1)

$$x(n) = \{2, 4, 6, 8\}$$

$$h(n) = \{2, -2, 4, 5\}$$

$$y(n) = \sum_{k=-\infty}^{\infty} x(k)\, h(n+k)$$

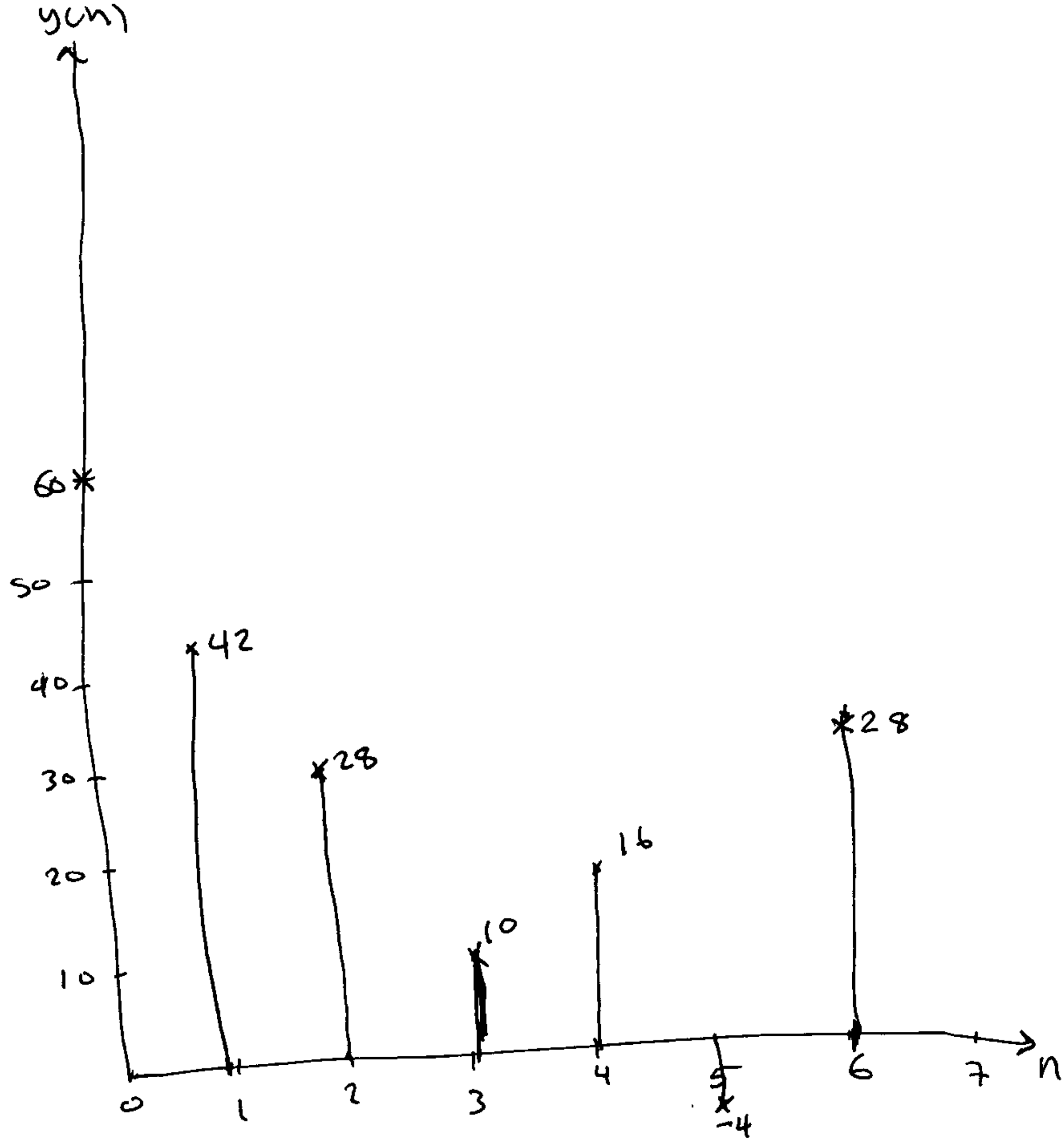
$$N = N_1 + N_2 - 1$$
$$= 4 + 4 - 1$$
$$= 7$$

o/p

$x(n) \rightarrow$	2	4	6	8	0	0	0	y(n)
	2	-2	4	5	0	0	0	60
	-2	4	5	0	0	0	2	42
	4	5	0	0	0	2	-2	28
	5	0	0	0	2	-2	4	10
	0	0	0	2	-2	4	5	16
	0	0	2	-2	4	5	0	-4
	0	2	-2	4	5	0	0	28

$$\therefore y(n) = \{60, 42, 28, 10, 16, -4, 28\}$$

الرسم في ظهر الورقة →



y(n)
60
50
40
30
20
10
42
28
10
16
-4
28
0
1
2
3
4
5
6
7
n