(1) Q P Code 65729

Q1(A)

_______ is one of the gas in GHG
a) **Carbon dioxide** b) Nitrogen c) Oxygen d) none
It measures the ability of system to work on various platform
a) Supportability b) Dependability c) **Portability** d) Efficiency
Server which contains machine with power and network cabling for each unit.
a) Blade server b) Rack server c)**Both a and b** d)None
_______ copies files based on their temporal locality to other disks and cannot be applied to online storage.
a) **MAID** b) Green Store c) RAID d) PDC
Reuse, recycle, __________ and Earth chater are well known Sustainability Principles.
a) Refurbish b) Regenerate c) **Reduce** d) None

Q1(B)

The 3 Rs of green IT are Reuse, Recycle and **Refurbish.**
Dependability is one of the usage related attributes.
TBL stands for **Triple Bottom Line.**
Service-Dominant Logic uses value in use concept.
Efficiency is one of the process related attributes.

Q1 (c)

A) Green IT, also known as green computing is the study and practice of designing, manufacturing and using computers, servers, monitors, printers, storage devices and networking and communications systems efficiently and effectively, with zero or min-imal impact on the environment. Green IT is also about using IT to support, assist and leverage other environmental initiatives and to help create green awareness.

B) Two techniques used
   a. Pre-fetching and caching
   b. Buffering
   c. OS manage the CPU frequency

C) It stands for **Storage Area Network.** It is the disc space appears as local to the client machine. This is a key point that enables the client (our data centre servers) to use disc management utility software to configure and optimize the space to best suit the needs of the server application.

D) a) Product Level
   b) Individual Level
   c) Functional Level
   d) Organizational Level

E) SICT stands for sustainable information and communication technology, It is the capability of an organisation to provide sustainability benefits internally and across the enterprises.

Q2

A) ***The Three Rs of Green IT***
Unwanted computers, monitors and other hardware should not be thrown away as rubbish, as they will then end up in landfills and cause serious environmental problems. Instead, we should refurbish and reuse them, or dispose them in environmentally sound ways. *Reuse*, *refurbish* and *recycle* are the three 'Rs' of greening unwanted hardware.

- **Reuse.** Many organizations and individuals buy new computers for each project or once every 2 – 3 years. Instead, we should make use of an older computer if it meets our requirements. Otherwise, we should give it to someone who could use it in another project or unit. By using hardware for a longer period of time, we can reduce the total environmental footprint caused by computer manufacturing and disposal.
- **Refurbish.** We can refurbish and upgrade old computers and servers to meet our new requirements. We can make an old computer and other IT hardware almost new again by reconditioning and replacing some parts. Rather than buying a new computer to our specifications, we can also buy refurbished IT hardware in the market. More enterprises are now open to purchasing refurbished IT hardware, and the market for refurbished equipment is growing. If these options are unsuitable, we can donate the equipment to charities, schools or someone in need, or we can trade in our computers.
- **Recycle.** When we cannot refurbish or otherwise reuse computers, we must dispose of them in environmentally friendly ways by depositing them with recognized electronic recyclers or electronic waste (e-waste) collectors. E-waste – discarded computers and electronic goods – is one of the fastest-growing waste types and poses serious envi-ronmental problems. The United Nations Environment Program estimates that 20 – 50 million tons of e-waste are generated worldwide each year, and this is increasing. IT hardware contains toxic materials like lead, chromium, cadmium and mercury. If we bury IT hardware in landfills, toxic materials can leach harmful chemicals into water-ways and the environment. If burned, they release toxic gases into the air we breathe. So if e-waste is not discarded properly, it can harm the environment and us. Waste electrical and electronic equipment (WEEE) regulations aim to reduce the amount of e-waste going to landfills and increase recovery and recycling rates.

B) **Environmental Impacts of IT**
IT affects our environment in several different ways. Each stage of a computer's life, from its production, through its use and to its disposal, presents environmental problems. Manufacturing computers and their various electronic and non-electronic components consume electricity, raw materials, chemicals and water, and generate hazardous waste. All these

directly or indirectly increase carbon dioxide emissions and impact the

C) environment.

Total electrical energy consumption by servers, computers, monitors, data communi-cations equipment and data centre cooling systems is steadily increasing. This increase results in greater GHG emissions, as most electricity is generated by burning fossil fuel like coal, oil and gas. For instance, each PC in use generates about a ton of carbon dioxide every year. Computer components contain toxic materials. Increasingly, con-sumers discard a large number of old computers, monitors and other electronic equipment 2 – 3 years after purchase, and most of this ends up in landfills, polluting the Earth and contaminating water.

The increased number of computers and their use, along with their frequent replace-ments, make IT's environmental impact a major concern. Consequently, there is increasing pressure on the IT industry, businesses and individuals to make IT environmentally friendly throughout its life cycle, from birth to death to rebirth. As many believe, it's our social and corporate responsibility to safeguard our environment.

C) Software Sustainability Attributes

To evaluate the sustainability performance of a given software system, we must first outline what attributes of the system we want to improve, and examine their impact and benefits

- **Development-related attributes:** These are the attributes that impact the development process, and key among them are the following:

  – Modifiability: The ability to make changes quickly and cost-effectively.

  – Reusability: The degree to which system components can be reused in other systems.

  – Portability: The ability of the system to run under different computing environ-ments.

  – **Supportability:** The system's ability to be easily configured and maintained after deployment.

- **Usage-related attributes:** These are the attributes that impact the usage at runtime. They are as follows:

  – Performance: The time the system takes to respond to user requests.

  – Dependability: The ability of a system to function as expected at any given time.

  – Usability: Features that make a system easy to use.

– Accessibility: The system's ability to allow users to access the system regardless of the user's location, or the type of computer or access device used.

- **Process-related attributes:** These are the attributes that impact project management. They are as follows:

  – Predictability: The ability to accurately estimate the effort and cost involved in developing software upfront.

  – Efficiency: The effort towards deliverables that add direct value to the customer, as opposed to the effort towards deliverables necessary to run the project.

  – Project carbon footprint: The net carbon emissions arising from the development of the software.

D) Context Awareness

Context awareness in computers means that they can sense the environment in which they are operating and software can be designed to react to changes in the environment.

Context awareness was first introduced by Schilit, Adams, and Want (1994, p. 89). The objective is to create applications that can respond or adapt to changes in the environment. For the physical environment, this requires sensors and the ability to generate events or state changes to which the applications can react. Examples of context-aware behaviour are as follows:

- A PC or smartphone warns you when your battery has reached a low-energy state.
- A notebook PC responds to a change from AC to DC power by automatically dimming the display.
- A tablet PC or smartphone responds to ambient light level and adjusts display bright-ness.
- A notebook PC quickly parks the hard drive heads when sensors detect that the device is falling – to avoid a head crash.
- A handheld device writes cached data to flash memory when the battery is getting critically low.

  Advantages:

  Power Source awareness

  Platform power policies

E) Green disposal. Refurbish and reuse old computers, and properly recycle unwanted computers and other electronic equipment.

All electronic waste is made up of deadly chemicals such as lead, cadmium, beryllium. mercury and brominated flame retardants. Disposing of gadgets

and devices improperly increases the chances of these dangerous chemicals contaminating the soil, polluting the air and leaching into water bodies. When e-waste is deposited in a landfill, it tends to leach when water passes through it picking up trace elements. After which the contaminated landfill water reaches natural groundwater with increased toxic levels, this can be harmful if it enters any drinking water bodies.
Give Your Electronic Waste to a Certified E-Waste Recycler
Upgrade your computer instead of simply replacing it

F) Green Devices
Devices having minimal or zero negative effects on environment.
1) Data Servers
2) End user computers
3) Mobile devices
4) Peripherals

Q3

A) 1 **Server Farm (Cluster)**

Cluster computing is characterized by multiple, physically discrete machines, closely linked to provide the logical interface of a single machine. Often associated with the parallelization of processing algorithms, cluster computing requires dedicated and highly specialized middleware to form the complex message-passing infrastructure required to manage the cluster's physical resources. The parallel processing capability would split and schedule individual requests across the large number of individual server machines, each configured to compute a result. The results of individual processes would then be collated together to form the final result. The savings in parallelizing the workload is the principle use and research interest for cluster computing.

2 **Cloud Computing**

The combination of SOA and virtualization gave rise to a further innovation in computing resource provision: cloud computing. Cloud computing makes a separation of concerns between *service*, *platform* and *infrastructure*, with each of these layers being virtualized and provided as a service in itself. Networking is used to communicate between different service layers and the application services supported.Infrastructure as a Service (IaaS) provides the fundamental virtual machine upon which a server may be built. Platform as a Service (PaaS) enables the provision of the required software platform stack upon which the final service is designed to run. Finally, Software as a Service (SaaS) enables the specific application to be packaged as a service and deployed on the virtual platform. This stack of virtualized services enables a complete large-scale server system to be built and deployed across the IT infrastructure of the data centre. The approach maximizes the use of hardware resources with each physical machine hosting a number of virtual machines.

B) IT Infrastructure Components:

1) Servers

3) Storage

4) IT platforms

C) To reduce the energy consumption of hard disks, different techniques and methodologies are being adopted. Three commonly used energy management techniques for hard disks are state transitioning, caching and dynamic RPM.

State Transitioning: Given that in a hard disk, the spindle motor consumes most of the power, state-transitioning techniques try to turn off the spindle motor or keep it in standby mode during idle periods. The disk transitions to standby or off mode if there is no request to be served. If the disk idle period is not long enough, the time overhead of *spin down* and *spin up* can affect the disk response time significantly. Moreover, the power consumed by transitioning itself might exceed the power saving gained from a low-power state during the short idle period.

Caching: In order to speed up access for both read and write requests, enterprise storage solutions typically have huge amounts of cache in conjunction with regular disks. Further, to make use of the cache to aid in disk power management, various techniques are recommended. These cache management techniques or algorithms aim to minimize disk power usage, either by minimizing disk access or by increasing the length of idle periods.

Dynamic RPM: Dynamic RPM in which the rotation speed of a hard disk is varied based on workload is another technique for hard disk energy management. It assumes availability of multispeed hard disks, and power consumption increases with the speed of rotation.

D) Business Drivers of Green IT Strategy:

Cost Reduction

Demands from Legal and Regulatory Requirements

Sociocultural and Political Pressure

Enlightened Self-Interest

Collaborative Business Ecosystem

New Market Opportunities

E) *System-Level Energy Management*

RAID with Power Awareness

Power-Aware Data Layout

Hierarchical Storage Management

Storage Virtualization

Cloud Storage

F) Organizational considerations in a green IT strategy

Key practical factors that need to be recognized and considered in the creation of a comprehensive green IT strategy for businesses are as follows:

- Base the green IT strategy on a firm belief that carbon footprint reduction and man-agement are not averse to achieving business outcomes – and, in fact, could leverage business outcomes.

- Stay abreast of the holistic and subjective nature of the concept of a green enterprise that encompasses personal, individual and attitude challenges.
- Move away from the desire of organizations to focus only on gaining immediate benefits towards a more holistic approach. The attractiveness of the so-called low-hanging fruits – such as immediately switching off physical carbon-emitting hardware (e.g. monitors and data servers) – may shadow potentially holistic carbon reduction.
- Create multiple provisions to tackle the uncertainty of legislation and standards relating to carbon emissions.
- Integrate an organization's existing packages and systems with CEMS.
- Incorporate cost – benefit analysis in metrics associated with green projects, thereby focussing on payback on the environmental initiatives.
- Manage risks associated with the use of technology-based initiatives such as cloud computing, BI and knowledge management in the area of green initiatives.
- Pay due consideration to the design and construction (wherever possible) of buildings and associated infrastructures. There is opportunity for substantial reduction in the emissions of an infrastructure if attention is paid to its initial design and construction from a carbon reduction viewpoint.
- Consider data centres as specialized buildings that house data and computing servers as well as an organization's network equipment – requiring strategic attention in the early stages of their construction and installation.
- Provide education and training (attitude and culture) to the staff to change current attitudes and outline the path for change, but also consider green human resources support that encourages attitude changes.
- Consider and make provisions for technology (hardware, servers and network) upgrades that will invariably occur as the organization strategizes for a green transformation. This consideration includes reusing and recycling existing hardware as well as implementing strategies for replacing it with new, more carbon-efficient hardware.
- Consider applications and systems upgrades in two major areas – firstly, to upgrade existing applications and systems to enable the incorporation of carbon data within them and, secondly, to strategize for new CEMS that is dedicated to collecting, storing, analysing and reporting only on carbon data.
- Undertake green process reengineering and management – making use of erstwhile reengineering strategies that include identification, modelling and process optimization

- Include green metrics and measurements that form part of identifying an organization's 'as is' state and modelling its 'to be' state.
- Ensure that legal compliance is an integral part of green IT strategies. Legal require-ments can vary from local and state legislations to carbon legislations at the national level. There are also international consortiums and summits that dictate legal require-ments and need to be incorporated in the ERBS.

Q4)

A) Organizational Level Information:

Whilst specific measures may differ, sustainability is important to organizations from all sectors – from service-based organizations to manufacturing organizations, from national government to local authorities and city councils. Sustainability strategy and direction are determined at the organization level based on macro concerns; identifying the overall sustainability goals of the organization, determining the types of businesses and activities in which the organization should be involved and defining organizational responsibilities.Organizations need to determine their goals and objectives for sustainability. Typically, organizational sustainability goals involve one or more of the following:

- Develop significant capabilities and a reputation for sustainability leadership.
- Keep pace with industry or stakeholder expectations.
- Meet minimum compliance requirements and reap readily available benefits.

Agreeing on one's desired business posture on sustainability will have a significant impact on business and thus on necessary goals and priorities. It is important to be clear about the organization's business objectives and the role of sustainability in enabling those objectives.

Performance metrics and KPIs are used to measure environmental, social and economic impacts, and to ensure the delivery of strategic (and sustainability-related) objectives. Further, they help to ensure the alignment of organizational activities and performance to sustainable strategy. Sustainability performance measures and KPIs help organizations to establish progress against sustainability goals and to ensure that they cover their environ-mental, social and economic impacts. A sample of widely used TBL KPIs typically found in organization level sustainability reports, also known as integrated reporting

B) **Sustainability Hierarchy Models**

Sustainability is a complex and broad subject. In order to make sense of the various frameworks and tools, Hitchcock and Willard (2008) created a hierarchy of sustainability models that is illustrated in Figure 9.1.

Natural laws: The laws imposed upon us by Mother Nature such as the Law of Conservation of Mass and Energy, Law of Entropy and Laws of Thermodynamics.
Frameworks: High-level conceptual rules for sustainability that conform to natural laws.
Principles: General and sector-specific guidelines that detail sustainable practices

Tools: Methodologies, standards and strategies for implementation.

C)

Roadmap category	First wave: green IT	Second wave: SITS
Time horizon	Present	Near term
	Near term	Intermediate term
Market segments	Cost-centric segments (reduce energy	Corporate sustainability segments
	costs and environmental footprint)	(sustainable IT innovation
	Data centres	leadership)
	IT operations	Eco-proactive
		Social-proactive
Products and	Green IT products and systems	IT-enabled corporate sustainability
services	Green data centre and	services
	energy-efficient products	Sustainable IT services (SITS)
	Green IT operations and eco-	Social-sustainable SITS
	and cost-efficient products	Eco-sustainable SITS
Technologies	Leverage technology for IT efficiency	Leverage technology for competitive
	Virtualization, server design,	advantage
	power and workload mana-	SITS applications
	gement, infrastructure, cloud	SaaS
	computing, green buildings,	Mobile cloud
	green tech, green tech,	Remote sensing
	e-waste, DfE, DfR, and so on	Smart systems
Compliance,	Green IT regulations and standards	Environmental and social reporting
regulations,	WEEE, EuP, RoHS, REACH,	Triple bottom line, CS and CSR
standards and	EPEAT, Energy Star, EPA,	reports, NGO reporting,
reporting	LEED, ISO 14000, Green	environmental-social reporting
	ITIL and so on	and integrated

		reporting
Organizational	Traditional IT organization with	Sustainable IT organization
changes	green elements	Sustainable IT aligns with CS
	IT organization with green IT	or CSR
	functions	Integrated sustainable IT culture
	IT organization with sustainable	
	IT office	
Value goals	Business value is primary focus	Customer value and societal value
	Customer value is secondary	focus
		Business value is achieved as a
		result

D)

Inter-organizational Enterprise Activities

A number of inter-organizational enterprise (extended enterprise) activities can be made greener by leveraging IS and technologies. Among them are three activities that are gaining growing interest: electronic commerce and purchasing, reverse logistics and demanufacturing operations as well as eco-industrial parks (Sarkis, 2006). These activities Reduction and elimination of environmentally sensitive materials

Compliance with provisions of European RoHS directive upon its effective date Reporting on amount of mercury used in light sources (mg)
Elimination of intentionally added short-chain chlorinated paraffin (SCCP) flame retardants and plasticizers in certain applications

Materials selection
Declaration of postconsumer recycled plastic content (%)
Declaration of renewable or bio-based plastic materials content (%)
Declaration of product weight (lbs.)

Design for end of life
Identification of materials with special handling needs
Elimination of paints or coatings that are not compatible with recycling or reuse
Easy disassembly of external enclosure
Marking of plastic components
Identification and removal of components containing

Product longevity or life cycle extension
  Availability of additional three-year warranty or service agreement
  Upgradable with common tools

Energy conservation
  Energy Star□
End-of-life management
  Provision of product take-back service
  Provision of rechargeable battery take-back service

Corporate performance
  Demonstration of corporate environmental policy consistent with ISO 14001
  Self-certified environmental management system for design and manufacturing organizations Corporate report consistent with the EPA's Performance Track or the Global Reporting
    Initiative (GRI)

Packaging
  Reduction or elimination of intentionally added toxics in packaging
  Separable packing materials
  Declaration of recycled content in packaging

E)

Life-Cycle Assessment

Life-cycle assessment (LCA), also known as life cycle analysis, is a technique to system-atically identify resource flows and environmental impacts associated with all the stages of product and service provision. LCA provides a quantitative cradle-to-grave analysis of the products or services' global environmental costs (i.e. from raw materials through materials processing, manufacture, distribution, use, repair and maintenance and disposal or recycling). The demand for LCA data and tools has accelerated with the growing global demand to assess and reduce GHG emissions from different manufacturing and service sectors (Horne, Grant, and Verghese, 2009).

LCA can be used as a tool to study the impacts of a single product to determine the stages of its life cycle with most impact (Levi Strauss & Co., 2009). LCA can also be used as decision support when determining the environmental impact of two comparable products or services (Goleman and Norris, 2009).

The Four Stages of LCA

For a LCA, both ISO 14040 (ISO, 2006a) and 14044 (ISO, 2006b) standards follow four distinct phases process, which are briefly described here.

1. **Goal and scope definition:** It is important to ask the right question to ensure whether the LCA is successful. The first step in this process is the framing of the key questions for the assessment. Typical steps include defining the goal(s) of the study, determining what type of information is needed to inform decision makers, defining functional units (environmental impact, energy efficiency, life

span, cost per use, etc.), defining the system boundaries and studying perspective, allocation principles, environmental impact assessment categories and level of detail.

2. **Inventory analysis:** The second phase involves data collection and modelling of the product and service system with process flow models and inventories of resource use and process emissions. The data must be related to the functional unit defined in the goal and scope definition and include all data related to environmental (e.g. CO_2) and technical (e.g. intermediate chemicals) quantities for all relevant unit processes within the study boundaries that compose the product system. Examples of inputs and outputs include materials, energy, chemicals, air emissions, water emissions, solid waste, radiation and land use. The results of a life cycle inventory provide verified information about all inputs and outputs in the form of elementary flow to and from the environment from all the unit processes involved in the study.
3. **Impact assessment:** The third phase evaluates the contribution to selected impact assessment categories, such as 'climate change', 'energy usage' and 'resource deple-tion'. Impact potential of the inventory is calculated and characterized according to the categories. Results can then be normalized across categories (same unit) and weighted according to the relative importance of the category; both of these actions are voluntary according to the ISO standard.
4. **Interpretation:** The final phase involves interpretation of the results to determine the level of confidence and communicate them in a fair, complete and accurate manner. This is accomplished by identifying the data elements that contribute significantly to each impact category, evaluating the sensitivity of these significant data elements, assessing the completeness and consistency of the study and drawing conclusions and recommendations based on a clear understanding of how the LCA was con-ducted and the results were developed (Skone, 2000).

F)

SITS Strategic Framework

Although the need for the development of strategies for the development and delivery of SITS has been apparent for many years, there is no extant body of literature on strate-gies or best practices. But SITS strategy is nascent and being pursued on a fragmented, incremental, 'greener IT' basis (Daoud, 2008; Deloitte Touche Tohmatsu, 2009).

As the imperative to develop a SITS orientation becomes more apparent (as it has for companies such as IBM and HP), IT managers will need to consider the full CS impact of their product and service designs in addition to the traditional focus on costs and business value generation. The primary driver of sustainable IT, both green IT and SITS, is CS, especially as it applies to a firm's impact on the economy, environment and society at large (Savitz and Weber, 2006; Zarella, 2008). Therefore, IT managers will need to work across the functional areas of the organization to ensure an integrated organization-wide SITS strategy that aligns with overall CS strategy.

SITS development and deployment will likely to be slower than that of green IT. It will take time for firms to understand a market that is earlv in its formation.