University of Ruhuna- Faculty of Technology

Bachelor of Information and Communication Technology
Level 2 (Semester I) Examination, June 2026
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Course Unit: ICT2142 Object Oriented Analysis and Design **Duration: 2 hours**

Instructions:

- This examination paper contains eight (08) pages, including the instruction page.
- Answer every question.
- All questions carry equal marks.

Question 01

(a) Consider the following scenario related to a Smart Waste Management System (SWMS) and answer the questions that follow.

A city council provides a SWMS that allows resident users to schedule and manage household waste collection services online. A registered resident logs into the waste management portal or mobile application using credentials to access system services.

After logging in, the resident can submit a request for waste collection by selecting the type of waste to be collected, such as general waste, recyclable materials, electronic waste, or garden waste. The resident then selects a preferred collection date and time and submits the request.

The system verifies the resident's account details and checks the availability of waste collection vehicles and collection officers in the selected area. If the requested collection slot is available, the system confirms the booking, assigns a waste collection officer and a collection vehicle automatically, and updates the waste collection schedule.

A confirmation notification containing the collection details is sent to the resident through email or SMS using an Email/SMS Notification Service. The residents can also track the collection schedule and receive notifications regarding delays or status updates.

If the selected collection slot is unavailable, the system displays an error message and suggests alternative dates and times for collection. If the resident requests hazardous or electronic waste collection, the system may require an additional service fee, which is processed through a payment gateway system before confirming the request.

On the scheduled collection date, the assigned waste collection officer collects the waste and updates the collection status through the system. The system records the completion of the task and updates the waste collection records automatically.

The system uses a vehicle tracking system to monitor and manage the location and assignment of waste collection vehicles during operations.

Certain external organizations, such as the City Council Environmental Monitoring Unit, may access reports generated by the system for monitoring and regulatory purposes, although they do not directly interact with daily operations.

If the system or server becomes unavailable, an error message is displayed and the resident is advised to try again later.

i. Briefly describe the following use case modeling concepts:
   - System under Discussion (SuD)
   - Primary Actor
   - Supporting Actor
   - Offstage Actor

[8 marks]

ii. Identify the following for the above system:
   - The System under Discussion (SuD)
   - Three (03) primary actors
   - Three (03) supporting actors
   - Two (02) possible offstage actors

[10 marks]

iii. Prepare an Actor–Goal List for the identified primary actors of the SWMS. Each actor should have a minimum of four (04) goals.

[12 marks]

iv. Define three (03) suitable use cases for the SWMS using appropriate use case naming conventions.
   - "Request Waste Collection" has already been identified as a use case.
   - Therefore, identify and write any other three (03) suitable use cases for the system.

[06 marks]

v. Construct a Fully Dressed Use Case for the use case "Request Waste Collection", including the following sections:
   - Use Case Name
   - Primary Actor
   - Supporting Actors
   - Preconditions
   - Main Success Scenario
   - Extensions / Alternative Flows

[24 marks]

(b) Read and construct a complete UML Use Case Diagram for the Smart Campus Fitness & Wellness Hub (SCFWH) based only on the provided scenario.

The SCFWH platform distinguishes between two primary user classifications: Students and Faculty Staff. Both user groups inherit all standard operational permissions of a general Gym Member, allowing them to independently View Facility Schedules and View Real-Time Facility Occupancy data via their user dashboards.

All Gym Members are permitted to Book a Workout Session. To ensure campus compliance and physical security, the booking engine enforces a strict workflow: every single time a member attempts to book a session, the system must verify Member ID against the university's central active-directory database before the transaction can proceed.

During the booking workflow, several optional configurations can alter the execution path depending on specific runtime conditions or user choices:

- Condition 1: If a member is attempting a new workout routine or explicitly requests professional guidance, they can choose to add a Personal Trainer to the reservation. If this option is selected, the system is forced to query Trainer Availability as a mandatory sub-process before finalizing the booking.
- Condition 2: If the core system detects that the authenticated user holds a premium "VIP Tier" membership profile, the user is presented with a conditional option to reserve a Private Locker for their session.

When a Faculty Staff member authenticates, they are granted administrative privileges allowing them to manage schedules. Because scheduling operations vary significantly depending on the operational context, "Manage Schedules" acts as an abstract concept that is specialized into two distinct concrete behaviors: a staff member can either Create Fitness Class or Cancel Fitness Class. However, if a staff member executes a Cancel Fitness Class action, and the target class contains active student enrollments, the system must automatically execute an asynchronous routine to notify Enrolled Members via SMS/Email.

Finally, the system interacts heavily with external financial entities. Gym Members can Process Membership Payments. The execution of any payment workflow mandatorily relies on an external Third-Party Payment Gateway api to authorize the transaction. Furthermore, if a payment transaction fails due to insufficient funds or expired credentials, an automated recovery path is triggered, allowing the member to register a payment dispute with the help desk.

[40 marks]

Question 02

(a) Actions are the elemental unit of behavior in an activity diagram.
List down the three (03) main features of actions and briefly explain each feature in your own words.

[24 marks]

(b) The following descriptions explain the purposes of different UML Activity Diagram elements.

Write the most suitable UML Activity Diagram element for each description.

No	Description / Purpose	UML Element
a	Represents the point where the workflow begins	
b	Splits a single flow into multiple concurrent activities	
c	Synchronizes multiple parallel activities before continuing the workflow	
d	Used to select one path among several alternative flows based on conditions	
e	Combines multiple alternative paths into a single flow	
f	Represents a specific task, operation, or process within the workflow	
g	Indicates the direction of execution between activities	
h	Represents the completion of the workflow or process	

[24 marks]

(c) Draw the corresponding UML Activity Diagram for the following use case narration, "Dental Treatment Appointment Booking" in an Online Dental Service System.

Use Case Name	Dental Treatment Appointment Booking
Goal in context	This use case describes the process of booking a dental treatment appointment through an online dental service system by entering patient details, selecting treatment types, validating insurance information, and confirming the appointment.
Primary Actor	Patient
Supporting Actors	Dental Service System, Insurance Verification Service, Dentist
Pre-conditions	Patient has opened the application and the home page is displayed.
Post-conditions	Appointment is successfully booked and the appointment confirmation page is displayed.
Triggers	This use case begins when the patient clicks on the "Book Dental Appointment" link on the home page.

Typical Course of Events	
Step	**Action**
1	Patient clicks on the "Book Dental Appointment" link.
2	The system displays the appointment booking form.
3	Patient enters NIC number, patient name, mobile number, preferred appointment date, and selects the treatment type.
4	Patient clicks the [NEXT] button.
5	The system validates all entered details.
6	The system sends an OTP code to the patient's mobile number for verification.
7	Patient enters the received OTP and clicks the [VERIFY] button.
8	The system validates the OTP.
9	The system performs two parallel activities simultaneously: • Checks dentist availability for the selected date.

	• Verifies patient insurance details with the Insurance Verification Service.
10	The system waits until both processes are completed.
11	The system displays available appointment time slots.
12	Patient selects a preferred time slot and clicks the [CONFIRM] button.
13	The system generates the appointment confirmation and displays the payment page.
14	Patient selects a payment method and completes the payment.
15	The system displays the appointment confirmation page and sends a confirmation SMS/email to the patient.
Alternative Courses	
Step	**Action**
8	If the OTP is incorrect, the system displays an "Invalid OTP" message and directs the patient back to Step 7.
9	If no dentist is available on the selected date, the system displays alternative available dates and returns to Step 11.

[52 marks]

Question 03

(a) Based on the scenario below, provide answers:

A university uses an Online Library Management System to manage its library. The system handles users, books, borrowing, and digital resources.

The users:
- Students can search for books, borrow available books, and access digital learning materials.
- Librarians can manage book records, update book availability, and approve or reject borrowing requests.

The books:
- Every book has these shared details: Book ID, Title, Author, and Availability Status.
- The system stores two kinds of books: printed books and e-books.
- E-books have one extra detail that printed books don't: a file format (for example, PDF or EPUB).

The borrowing process:
- When a book is borrowed, the system automatically checks if it is available, updates the borrowing record, and sets a return due date.
- Users do not see how these steps happen inside the system; this keeps the system simple and secure.

i. Identify the Object-Oriented Programming (OOP) concepts used in the system.

[08 marks]

ii. For each OOP concept identified in part (i), provide ONE suitable example taken directly from the library system scenario above.

[16 marks]

(b) Indicate whether each statement is **True** or **False**.

i. A class diagram represents the dynamic behavior of a system over time.

ii. A class defines attributes and methods that describe the structure and behavior of objects.

iii. Multiplicity in a class diagram defines how many methods a class can have.

iv. Composition is a weak relationship where child objects can exist independently of the parent.

v. A dependency relationship indicates a strong ownership between classes.

[15 marks]

(c) Consider the following case study and answer the questions that follow.

An Information System is proposed for BrandSphere, a rapidly growing Online Digital Branding and Social Media Management Platform used by businesses and influencers to manage their online branding activities. As the number of users increased, the management decided to automate campaign handling, creator collaboration, media management, and payment processing through a centralized information system.

When a new business or influencer joins BrandSphere, they must register as a client by providing their Client ID, company or influencer name, email address, contact number, business category, and subscription plan. After registration, clients can create branding campaigns to promote products, services, or personal brands across multiple social media platforms.

Each branding campaign created in the system is identified using a Campaign ID and stores information such as campaign name, start date, end date, budget, target audience, and campaign status. Clients can create, update, and monitor campaigns throughout their subscription period. A single client may manage several campaigns simultaneously.

To improve audience engagement, campaigns include multiple social media posts such as image posts, promotional videos, stories, and banners. For each social media post, the system stores the post ID, caption, scheduled publishing date, platform used (Instagram, TikTok, Facebook, etc.), reach count, and engagement rate. These posts are scheduled and managed under their respective campaigns.

BrandSphere also collaborates with professional content creators to improve campaign visibility. Each content creator registered in the platform has a Creator ID, creator name, specialization, follower count, and contact information. Since creators often work on multiple campaigns simultaneously, the system should maintain creator assignments across campaigns.

Every campaign automatically generates an analytics dashboard used to monitor campaign performance. The analytics dashboard records impressions, clicks, engagement statistics, audience demographics, and performance reports. The management noted that an analytics dashboard should not exist independently without an associated campaign because it is generated specifically for campaign analysis.

The platform maintains a centralized media library that stores branding resources such as images, videos, logos, and design templates. Campaigns can use several media files from

the media library, while the same media resource can also be reused in different campaigns. Even if a campaign is removed from the system, media files should remain stored in the media library for future use.

To increase campaign reach, clients can purchase advertisement packages offered by BrandSphere. When purchasing a package, payment details, including payment ID, payment date, amount paid, and payment method, are recorded in the system.

The platform employs Social Media Managers who are responsible for approving campaigns, assigning content creators, and generating campaign reports. In addition, System Administrators manage users, subscription plans, and payment records to ensure smooth operation of the platform.

i. Identify the actor(s) in the above system. [08 marks]

ii. 'Campaign' is one of the classes identified in the system.
   1. Identify five (05) attributes of the 'Campaign' class.
   2. Identify three (03) methods in the 'Campaign' class.

[16 marks]

iii. Client, Campaign, SocialMediaPost, ContentCreator, AnalyticsDashboard, MediaLibrary, Payment, and AdvertisementPackage are some of the classes identified in designing the system. Identify the relationships between these classes and draw a UML Class Diagram by indicating only the relationships and multiplicities.

[28 marks]

iv. Suppose the platform introduces premium payment methods:
   - Credit Card payments receive a 3% cashback reward.
   - Crypto payments receive a 5% promotional discount.

   Explain how the class diagram drawn in (iii) can be modified to accommodate this requirement.

[09 marks]

Question 04

(a) Consider the following scenario related to an Online Examination Management System.

A student uses an online examination system to take an exam.

First, the Student logs into the system by entering their username and password on the Exam Portal. The portal forwards these credentials to the Authentication Service, which verifies them and returns an authentication status to confirm whether the login is successful.

After successful login, the Student starts an exam by selecting an exam ID. The Exam Portal sends a request to the Exam Controller, which is responsible for managing exam flow. The Exam Controller retrieves the required questions from the Question Bank. The

Question Bank sends back the list of questions, and the Exam Controller forwards them to the Exam Portal, which then displays the questions to the Student.

Next, the Student submits answers through the Exam Portal. The portal sends these answers to the Result Processor for evaluation. The Result Processor fetches the correct answers from the Question Bank and then compares them with the student's responses. It calculates the marks using an internal self-call operation and then saves the result into the Database. The database confirms that the result has been stored successfully.

After processing, the Result Processor publishes the result, which is sent to the Notification Service. The Notification Service sends an email notification containing the result to the Student.

Finally, the Student logs out of the Exam Portal, ending the session.

i. Based on the above scenario, draw a Communication (Collaboration) Diagram showing the interactions between the participating objects.

[33 marks]

ii. Using the Communication (Collaboration) Diagram drawn in part (i), construct a Sequence Diagram only for the **answer submission and result processing functionality** (from the point where the Student submits answers until the result is published and notified to the Student).

[27 marks]

(b)

i. Write four (04) phases of the Rational Unified Process and list two (02) activities done in each phase.

[24 marks]

ii. "Unified Process is an iterative and incremental process." Do you agree with this statement? Justify your answer.

[16 marks]

---------- **End of the Paper** ----------