OLLSCOIL NA GAILLIMHE
UNIVERSITY OF GALWAY

Autumn Examinations 2022-2023

Course Instance Code(s)	3BCT, 3BDA
Exam(s)	B.Sc. (CS&IT), B.A. (Digital Arts & Technology)
Module Code(s)	CT3536
Module(s)	Games Programming
Paper No.	1

External Examiner(s)	Dr. R. Trestian
Internal Examiner(s)	Prof. M. Madden *Dr. S. Redfern

Instructions: Answer any three questions. All questions carry equal marks. Note that the final page of this exam paper lists useful classes from the Unity3D SDK.

Duration	2 hours
No. of Pages	4
School	Computer Science
Course Co-ordinator(s)	Dr. C. O'Riordan, Dr. P. Killeen

Requirements:

Release in Exam Venue	Yes [x]	No [ ]
MCQ Answersheet	Yes [ ]	No [x]
Handout	None	
Statistical/ Log Tables	None	
Cambridge Tables	None	
Graph Paper	None	
Log Graph Paper	None	
Other Materials	None	
Graphic material in colour	Yes [x] No [ ]	

PTO

Q.1.

(i) Making appropriate use of local and global co-ordinates, write Unity3D/C# code to perform the following transformations. You may assume that references to the runtime game objects are provided:

- rotate a game object 5 degrees around its own x axis [2]
- move a game object 6 units downwards in the world's co-ordinate system [2]
- move a game object 7 units directly towards another game object [3]
- move a game object 10 units forward in whatever direction it is facing [3]

(ii) Write code for the following method, which considers the supplied list of objects and returns the one which is furthest away from the specified 3D point: [10]

```
public static GameObject GetFurthestObject(List<GameObject> objects, Vector3 pos) {

}
```

Q.2.

Write technical notes (approx. 150 words) on *each* of the following:

(i) The use of State Machines to structure game logic. [5]
(ii) Screen space, viewport space and world space in Unity, including how to transform between them. [5]
(iii) The Object Pool pattern – why it's useful and how it operates. [5]
(iv) Coroutines in Unity, including two different situations for which Coroutines would be useful. [5]

Q.3.

(i) In 3D games development, what does the term **'raycast'** mean, as supported by various static methods of the Unity3D SDK's Physics class? Explain, with illustrative C# code, how you could use a raycast to allow the user to click with the mouse and select a game object from the scene. [10]

(ii) In a shooting game, assume you are using raycasts to determine what the player has hit when they fire their gun. You may assume that you are given a reference to the gun object in the 3D scene.

- Write appropriate Unity3D/C# code to perform a raycast when the gun is fired, to determine what is hit by the bullet. The gun should have a maximum range of 500 metres. [6]
- Write appropriate Unity3D/C# code to instantiate an 'explosion' object at the position that the bullet hits. You may assume that a prefab exists for this explosion object. [4]

PTO

Q.4.

(i) Write a C# Monobehaviour script to attach to a Unity3D game object which automatically destroys the object as soon as it is either behind the camera or more than a defined distance away from it. This defined distance should be available as a value that can be edited in the inspector. [8]

(ii) What are C# Coroutines? [2]

(iii) Write a Coroutine which carries out a sequence of actions over time: [8]

- Gradually (frame by frame) moves its local game object at a speed of 1 metre per second towards a Vector3 position.
- After the game object arrives at the position, waits 2 seconds.
- Then moves the game object in the same way to a second Vector3 position.

Your Coroutine should use the following signature:

```
IEnumerator MoveBetween(Vector3 pos1, Vector3 pos2)
{

}
```

(iv) Write a general-purpose version of your Coroutine which: [2]

- Moves the game object between each position in a List rather than just two positions.
- After arriving at each position, waits for the time defined in the Float, before continuing to the next Vector3 in the List.

Your Coroutine should use the following signature:

```
IEnumerator MoveBetween(List<Vector3> positions, float waitTime)
{

}
```

PTO

Some Useful Unity3D SDK Classes

GameObject: static methods

Instantiate()	Destroy()	DestroyImmediate()	Find()

GameObject: methods

AddComponent()	SendMessage()	GetComponent()	SetActive()

GameObject: data members

activeInHierarchy	transform	tag

MonoBehaviour: methods

Start()	OnDestroy()	Awake()	Update()
FixedUpdate()	LateUpdate()	OnDisable()	OnEnabled()
OnBecameInvisible()	OnBecameVisible()	OnCollisionEnter()	OnCollisionExit()
OnCollisionStay()	OnTriggerEnter()	OnTriggerExit()	OnTriggerStay()
SendMessage()	BroadcastMessage()	SendMessageUpwards()	GetComponent()
GetComponentInChildren()	GetComponentInParent()	GetComponents()	GetComponentsInChildren()
GetComponentsInParent()	GetInstanceID()	Invoke()	StartCoroutine()

MonoBehaviour: data members

enabled	gameObject	transform	name

Transform: methods

Rotate()	Translate()	TransformPoint()	InverseTransformPoint()
LookAt()	RotateAround()	SetParent()	TransformVector()
InverseTransformVector()	TransformDirection()	InverseTransformDirection()	

Transform: data members

position	localPosition	rotation	localRotation
lossyScale	localScale	parent	right
up	forward	gameObject	

Rigidbody: methods

AddForce()	AddForceRelative()	AddForceAtPosition()	AddTorque()
AddRelativeTorque()	MovePosition()	MoveRotation()	

Rigidbody: data members

drag	angularDrag	mass	velocity
angularVelocity	centerOfMass		

Camera: methods

ScreenToWorldPoint()	WorldToScreenPoint()	ScreenToViewportPoint()
ViewportToScreenPoint()	WorldToViewportPoint()	ViewportToWorldPoint()
ViewportPointToRay()	ScreenPointToRay()	

Physics: static methods

Raycast()	SphereCast()	OverlapBox()	BoxCast()

Input: static data members and methods

mousePosition	GetKey()	GetKeyDown()	GetMouseButton()
GetMouseButtonDown()			

END

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Autumn Examinations 2021-22

Course Instance Code(s)	3BCT, 3BDA
Exam(s)	BSc (CS&IT), BA (Digital Arts & Technology)
Module Code(s)	CT3536
Module(s)	Games Programming
Paper No.	1
External Examiner(s)	Dr. Ramona Trestian
Internal Examiner(s)	Prof. Michael Madden *Dr. Sam Redfern

Instructions: Answer any three questions.
All questions carry equal marks.
Note that the final page of this exam paper lists useful classes from the Unity3D SDK.

Duration	2 hours
No. of Pages	4
Discipline(s)	Computer Science
Course Co-ordinator(s)	Dr. Colm O'Riordan, Dr. Padraic Killeen

Requirements:

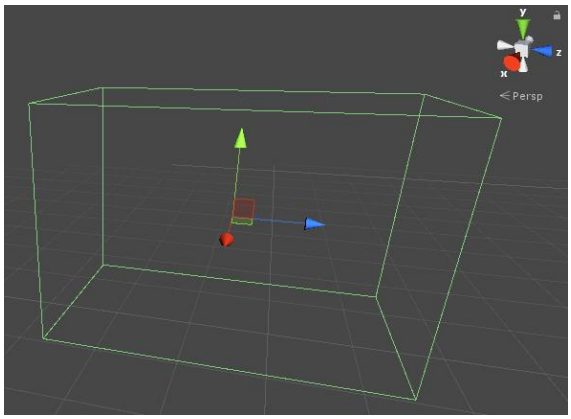
Release in Exam Venue	Yes	☐	No	☐
MCQ Answersheet	Yes	☐	No	☐

Handout	None
Statistical/ Log Tables	None
Cambridge Tables	None
Graph Paper	None
Log Graph Paper	None
Other Materials	None
Graphic material in colour	Yes ☑ No ☐

Q.1.

(i) Explain how Unity's MonoBehaviour class provides tight integration with the Game Loop. Refer to appropriate methods of the MonoBehaviour class in your answer. [6]

(ii) What is a Coroutine in Unity, and how do Coroutines integrate with the Game Loop? [4]



(iii) The Game Object depicted has a Box Collider component, whose 'isTrigger' property is true. A script on the game object contains a reference to the Box Collider and to a prefab of a ball.

```
public BoxCollider bc;
public GameObject ball;

public IEnumerator SpawnBallsInBox(){

}
```

Write code for the SpawnBallsInBox() coroutine, so that it continually instantiates balls, at a rate of one ball every two seconds. The balls should be initialised to a random position somewhere inside the Box Collider. (Hint: use the 'bounds' property of the Box Collider, which has 'min' and 'max' properties, each of which are of type Vector3). [10]

Q.2.

Making appropriate use of local and global co-ordinates, write Unity3D/C# code to perform the following transformations. You may assume that references to the runtime gameobjects are provided:

- rotate a gameobject 5 degrees around its own x axis [2]
- move a gameobject 6 units downwards in the world's co-ordinate system [2]
- move a gameobject 7 units directly towards another gameobject [3]
- move a gameobject 10 units forward in whatever direction it is facing [3]

(ii) Write code for the following method, which considers the supplied list of objects and returns the one which is furthest away from the specified 3D point: [10]

```
public static GameObject GetFurthestObject(List<GameObject> objects, Vector3 pos) {

}
```

Q.3.

(i) In 3D games development, what does the term '**raycast**' mean, as supported by various static methods of the Unity3D SDK's Physics class? Explain, with illustrative C# code, how you could use a raycast to allow the user to click with the mouse and select a gameobject from the scene. [10]

(ii) In a shooting game, assume you are using raycasts to determine what the player has hit when they fire their gun. You may assume that you are given a reference to the gun object in the 3D scene.

- Write appropriate Unity3D/C# code to perform a raycast when the gun is fired, to determine what is hit by the bullet. The gun should have a maximum range of 500 metres. [6]
- Write appropriate Unity3D/C# code to instantiate an 'explosion' object at the position that the bullet hits. You may assume that a prefab exists for this explosion object. [4]

Q.4.

(i) Bearing in mind that, in Unity's physics engine, gravity only operates along a fixed world vector, how could you simulate a moon orbiting a planet? Write Unity3D/C# code to achieve this, identifying the appropriate methods in which it should be written, as well as identifying the appropriate component(s) which have been added to the game objects. [10]

(ii) Write Unity3D/C# code to accomplish the following:

- instantiate a gameobject at runtime, from a prefab [2]
- obtain a reference to the Rigidbody component attached to it, if it has one [2]
- attach a new Rigidbody to the gameobject, if it did not have one already [3]
- set the gameobject moving in a straight line using the physics engine [3]

Q.5.

Write technical notes on each of the following [5 x 4]

(i) How you would display (and update) a score on the screen while a game is being played, using the Unity GUI system.
(ii) Garbage collection in Unity, including how to write low-garbage code.
(iii) Triggers and Colliders in Unity – how to use them and why they are useful for games development.
(iv) Screen space, viewport space and world space in Unity.

Some Useful Unity3D SDK Classes

GameObject: static methods

Instantiate()	Destroy()	DestroyImmediate()	Find()

GameObject: methods

AddComponent()	SendMessage()	GetComponent()	SetActive()

GameObject: data members

activeInHierarchy	transform	tag

MonoBehaviour: methods

Start()	OnDestroy()	Awake()	Update()
FixedUpdate()	LateUpdate()	OnDisable()	OnEnabled()
OnBecameInvisible()	OnBecameVisible()	OnCollisionEnter()	OnCollisionExit()
OnCollisionStay()	OnTriggerEnter()	OnTriggerExit()	OnTriggerStay()
SendMessage()	BroadcastMessage()	SendMessageUpwards()	GetComponent()
GetComponentInChildren()	GetComponentInParent()	GetComponents()	GetComponentsInChildren()
GetComponentsInParent()	GetInstanceID()	Invoke()	StartCoroutine()

MonoBehaviour: data members

enabled	gameObject	transform	name

Transform: methods

Rotate()	Translate()	TransformPoint()	InverseTransformPoint()
LookAt()	RotateAround()	SetParent()	TransformVector()
InverseTransformVector()	TransformDirection()	InverseTransformDirection()	

Transform: data members

position	localPosition	rotation	localRotation
lossyScale	localScale	parent	right
up	forward	gameObject	

RigidBody: methods

AddForce()	AddForceRelative()	AddForceAtPosition()	AddTorque()
AddRelativeTorque()	MovePosition()	MoveRotation()	

RigidBody: data members

drag	angularDrag	mass	velocity
angularVelocity	centerOfMass		

Camera: methods

ScreenToWorldPoint()	WorldToScreenPoint()	ScreenToViewportPoint()
ViewportToScreenPoint()	WorldToViewportPoint()	ViewportToWorldPoint()
ViewportPointToRay()	ScreenPointToRay()	

Physics: static methods

Raycast()	SphereCast()	OverlapBox()	BoxCast()

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Semester 1 Examinations 2021-22

Course Instance Code(s)	3BCT, 3BDA
Exam(s)	BSc (CS&IT), BA (Digital Arts & Technology)
Module Code(s)	CT3536
Module(s)	Games Programming
Paper No.	1
External Examiner(s)	Dr. Ramona Trestian
Internal Examiner(s)	Prof. Michael Madden
	*Dr. Sam Redfern

Instructions: Answer any three questions.
All questions carry equal marks.
Each question is worth a maximum of 20 marks. The total (out of 60) will be converted to a percentage after marking.
Note that the final page of this exam paper lists useful classes from the Unity3D SDK.

Duration	2 hours
No. of Pages	5
Discipline(s)	Computer Science
Course Co-ordinator(s)	Dr. Colm O'Riordan, Dr. Padraic Killeen

Requirements:

Release in Exam Venue	Yes	☐	No	☐
MCQ Answersheet	Yes	☐	No	☐

Handout	None
Statistical/ Log Tables	None
Cambridge Tables	None
Graph Paper	None
Log Graph Paper	None
Other Materials	None
Graphic material in colour	Yes ☑ No ☐

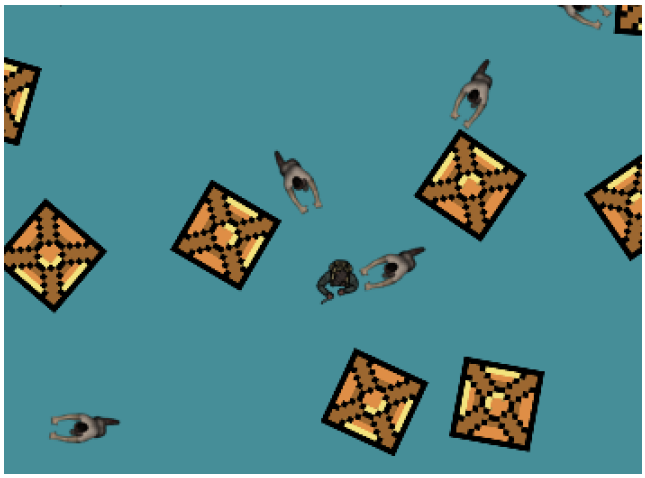
Q.1.

(i) Write a Unity C# script which you can attach to game objects to make them continually face towards the camera (even when they and/or the camera moves) [5]

(ii) In the two-dimensional game depicted in the image below, computer controlled 'zombies' chase the player. The zombie behaviour is controlled through a MonoBehaviour script called ZombieAI. Write Unity3D/C# code to rotate a zombie *a little* towards the player each frame, and indicate the appropriate method in the ZombieAI script into which this should be written. You can assume that zombies have access to the player game object via the static reference Player.activePlayer. Hint: use Vector3.RotateTowards() to calculate the result of rotating one vector towards another vector by a specified amount. [5]

(iii) Write additional code which will move the zombie in its own forwards direction in each frame, but only if the zombie is facing straight at (or almost straight at) the player. Hint: use Vector3.Dot (vector dot product). [5]

(iv) Without writing any code, explain (in plain English) how you could extend the ZombieAI class so that zombies only rotate and move towards the player if their line of sight is not blocked by any of the boxes depicted in the image below. Be as precise as possible in your explanation. Zombies' vision should only be blocked by boxes, not by other zombies. [5]



Q.2.

Write technical notes (approx. 150 words) on *each* of the following:

(i) The use of State Machines to structure game logic. [5]
(ii) Screen space, viewport space and world space in Unity, including how to transform between them. [5]
(iii) The Object Pool pattern – why it's useful and how it operates [5]
(iv) Coroutines in Unity, including two different situations for which Coroutines would be useful [5]

Q.3.

(i) In the Unity3D game engine, define the terms: Collider, Trigger, and Rigidbody. Explain one typical use of each of these in a game. [6]

(ii) Under what circumstances does the OnCollisionEnter( ) method get executed in a MonoBehaviour-derived script? Explain in general terms (no precise code required) how you could make use of the Collision.contacts argument received by OnCollisionEnter, to instantiate 'metallic spark' special effect prefabs at the points of contact, and have them correctly aligned so that the sparks move outwards from the surface of contact. [6]

(iii) Making appropriate use of local and global co-ordinates, write Unity3D/C# code to perform the following transformations. You may assume that references to the runtime game objects are provided:

- rotate a game object 5 degrees around its own z axis [2]
- move a game object 6 units upwards **per second**, in the world's co-ordinate system [3]
- move a game object 7 units directly towards another game object [3]

Q.4.

(i) Bearing in mind that, in Unity's physics engine, gravity only operates along a fixed world vector, explain (in plain English) how could you simulate a planet orbiting a sun. [3]

(ii) Write Unity3D/C# code to achieve this, identifying the appropriate methods in which it should be written, as well as identifying the appropriate component(s) which have been added to the game objects. [4]

(iii) Extend your code so that, in addition to a planet orbiting a sun, there is also a moon orbiting the planet. [5]

(iv) Write a single Unity (MonoBehaviour) C# script which is suitable for attaching to any game object that you wish to orbit around another game object. The script should offer inspector settings (i.e. public variables and object references) for defining the object being rotated around, as well as the axis of rotation and the speed of rotation. [8]

Q.5.

(i) In games development, what does the term 'raycast' mean, as supported by various static methods of the Unity3D SDK's Physics class (and Physics2D class)? [4]

(ii) Explain, with illustrative C# code, how you could use a raycast to determine whether a character in a game is standing on something. [6]

(iii) Write code for the following method, which considers the list of game objects sent to it, and returns the game object from that list which is closest to the specified 3D point: [10]

```
public static GameObject GetClosestObject(List<GameObject> objects, Vector3 point)
{

}
```

Some Useful Unity3D SDK Classes

GameObject: static methods

Instantiate()	Destroy()	DestroyImmediate()	Find()

GameObject: methods

AddComponent()	SendMessage()	GetComponent()	SetActive()

GameObject: data members

activeInHierarchy	transform	tag

MonoBehaviour: methods

Start()	OnDestroy()	Awake()	Update()
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GetComponentInChildren()	GetComponentInParent()	GetComponents()	GetComponentsInChildren()
GetComponentsInParent()	GetInstanceID()	Invoke()	StartCoroutine()

MonoBehaviour: data members

enabled	gameObject	transform	name

Transform: methods

Rotate()	Translate()	TransformPoint()	InverseTransformPoint()
LookAt()	RotateAround()	SetParent()	TransformVector()
InverseTransformVector()	TransformDirection()	InverseTransformDirection()	

Transform: data members

position	localPosition	rotation	localRotation
lossyScale	localScale	parent	right
up	forward	gameObject	

RigidBody: methods

AddForce()	AddForceRelative()	AddForceAtPosition()	AddTorque()
AddRelativeTorque()	MovePosition()	MoveRotation()	

RigidBody: data members

drag	angularDrag	mass	velocity
angularVelocity	centerOfMass		

Camera: methods

ScreenToWorldPoint()	WorldToScreenPoint()	ScreenToViewportPoint()
ViewportToScreenPoint()	WorldToViewportPoint()	ViewportToWorldPoint()
ViewportPointToRay()	ScreenPointToRay()	

Physics: static methods

Raycast()	SphereCast()	OverlapBox()	BoxCast()

Input: static data members and methods

mousePosition	GetKey()	GetKeyDown()	GetMouseButton()
GetMouseButtonDown()			

Semester 1 Examinations 2019-20

Course Instance Code(s)	3BCT
Exam(s)	BSc (CS&IT)
Module Code(s)	CT3536
Module(s)	Games Programming
Paper No.	1
External Examiner(s)	Dr. Jacob Howe
Internal Examiner(s)	Prof. Michael Madden *Dr. Sam Redfern

Instructions: Answer any three questions.
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Duration	2 hours
No. of Pages	5
Discipline(s)	Computer Science
Course Co-ordinator(s)	Dr. Des Chambers

Requirements:

Release in Exam Venue	Yes	☐	No	☐
MCQ Answersheet	Yes	☐	No	☐

Handout	None
Statistical/ Log Tables	None
Cambridge Tables	None
Graph Paper	None
Log Graph Paper	None
Other Materials	None
Graphic material in colour	Yes ☑ No ☐

Q.1.

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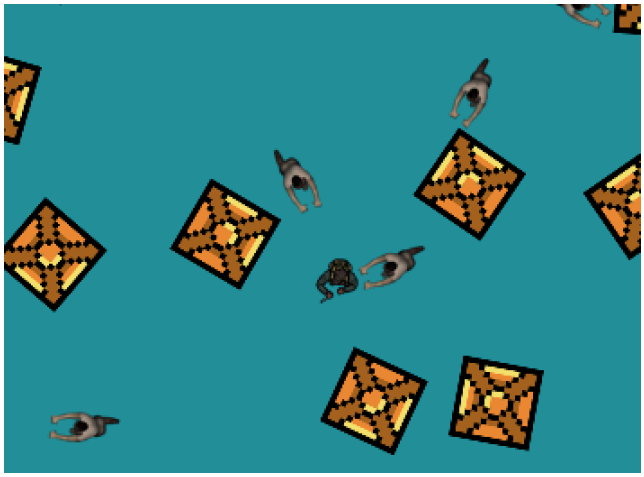
(iii) In the two-dimensional game depicted in the image below, computer controlled 'zombies' chase the player. The zombie behaviour is controlled through a MonoBehaviour script called ZombieAI. Write Unity3D/C# code to rotate a zombie a little towards the player each frame, and indicate the appropriate method in the ZombieAI script into which this should be written. You can assume that zombies have access to the player game object via the static reference Player.activePlayer. Hint: use Vector3.RotateTowards() to calculate the result of rotating one vector towards another vector by a specified amount. [5]

(iv) Write additional code which will move the zombie in its forwards direction in each frame, but only if the zombie is facing straight at (or almost straight at) the player. Hint: use Vector3.Dot (vector dot product). [5]



Q.2.

Write technical notes on each of the following:

(i) How you would display (and update) a score on the screen while a game is being played, using the Unity GUI system. [5]
(ii) Garbage collection in Unity, including how to write low-garbage code. [5]
(iii) The use of State Machines to structure game logic. [5]
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(iii) Making appropriate use of local and global co-ordinates, write Unity3D/C# code to perform the following transformations. You may assume that references to the runtime game objects are provided:

- rotate a game object 5 degrees around the world's y axis [2]
- move a game object 7 units directly towards another game object [3]
- move a game object 10 units forward in whatever direction it is facing [3]

Q.4.

(i) Bearing in mind that, in Unity's physics engine, gravity only operates along a fixed world vector, how could you simulate a planet orbiting a sun? Write Unity3D/C# code to achieve this, identifying the appropriate methods in which it should be written, as well as identifying the appropriate component(s) which have been added to the game objects. [7]

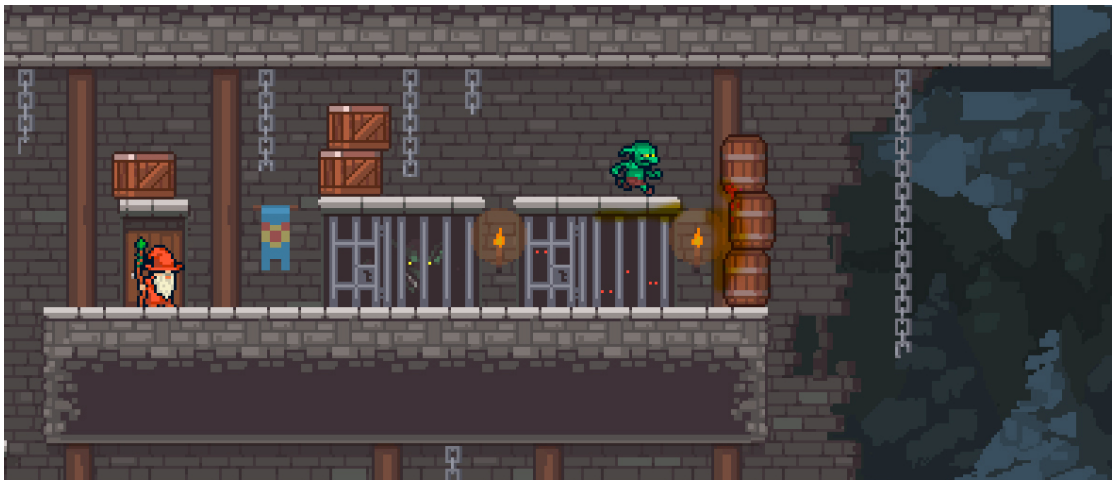
(ii) Extend your code so that, in addition to a planet orbiting a sun, there is also a moon orbiting the planet. [5]

(iii) Write a single Unity (MonoBehaviour) C# script which is suitable for attaching to any game object that you wish to orbit around another game object. The script should offer inspector settings (i.e. public variables and object references) for defining the object being rotated around, as well as the axis of rotation and the speed of rotation. [8]

Q.5.

(i) In games development, what does the term 'raycast' mean, as supported by various static methods of the Unity3D SDK's Physics class (and Physics2D class)? Explain, with illustrative C# code, how you could use a raycast to determine whether a character in a game is standing on something. [10]

(ii) In the two-dimensional game depicted below, the game characters have Rigidbody2D and Collider2D components, are moved left and right using the left/right arrow keys, and can jump upwards when the up arrow key is pressed – but only if they are standing on something. Their movement is controlled by the physics engine. Write suitable Unity3D/C# code to implement these movement behaviours for a character, indicating which methods the code is written in. [10]



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SendMessage()	BroadcastMessage()	SendMessageUpwards()	GetComponent()
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GetComponentsInParent()	GetInstanceID()	Invoke()	StartCoroutine()

MonoBehaviour: data members

enabled	gameObject	transform	name

Transform: methods

Rotate()	Translate()	TransformPoint()	InverseTransformPoint()
LookAt()	RotateAround()	SetParent()	TransformVector()
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Transform: data members

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AddForce()	AddForceRelative()	AddForceAtPosition()	AddTorque()
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RigidBody: data members

drag	angularDrag	mass	velocity
angularVelocity	centerOfMass		

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ViewportToScreenPoint()	WorldToViewportPoint()	ViewportToWorldPoint()
ViewportPointToRay()	ScreenPointToRay()	

Physics: static methods

Raycast()	SphereCast()	OverlapBox()	BoxCast()

Input: static data members and methods

mousePosition	GetKey()	GetKeyDown()	GetMouseButton()
GetMouseButtonDown()			