Higher National Unit specification

General information for centres

Unit title: Game Physics

Unit code: F86H 35

Unit purpose: This Unit is designed to enable candidates to implement real world physics, as realistically as possible, into real-time physics simulations within a computer game.

On completion of the Unit the candidate should be able to:

1 Demonstrate a clear understanding of the physics and associated maths that are used in modern computer games and identify different scenarios in computer games where they are implemented to improve the realism of the simulation.
2 Create a solution for a realistic physics simulation by applying physics for a chosen scenario within a computer game.
3 Implement game physics by coding a physics simulation in a modern programming language for a chosen scenario within a computer game.

Credit points and level: 2 HN credits at SCQF level 8: (16 SCQF credit points at SCQF level 8*)

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

Recommended prior knowledge and skills: Access to this Unit is at the discretion of the centre. However, it is recommended that candidates should possess Higher Physics or Higher Maths or equivalent HN Units. Candidates should also have some experience of at least one high level programming language such as C++, Java or C#.

Core Skills: The achievement of this Unit gives automatic certification of the following:

- Critical Thinking at SCQF level 6
- *Numeracy* at SCQF level 6

Context for delivery: If this Unit is delivered as part of a Group Award, it is recommended that it should be taught and assessed within the subject area of the Group Award to which it contributes.

This Unit is included in the framework of the HND in Computer Games Development and can be delivered as part of that Award. It is recommended that it should be taught and assessed within the subject area of the Group Award to which it contributes. The most appropriate approach to delivery within a Group Award is to implement the physics simulation described in Outcomes 2 and 3 within a computer game developed as evidence of assessment for one of the programming Units in the award. This would allow for a degree of cross assessment for Outcome 3.

General information for centres (cont)

Assessment: It is recommended that the knowledge and understanding required in Outcome 1 should be assessed using a 40 question multiple-choice assessment and should be conducted as a closed-book assessment under supervised conditions. This multiple-choice assessment can be paper based or carried out via an on-line assessment.

If a centre is presenting the closed-book assessment for Outcome 1 on-line the following assessment methods, where appropriate, may be selected:

- Multiple-choice
- Drag and drop
- Multiple response
- Mix and match
- A combination of the above

Outcomes 2 and 3 should be open book under supervised conditions and may be integrated into one assessment. The evidence for this assessment should include a solution involving physics and maths to a scenario within a computer game where a real-time physics simulation is required. It is recommended that this solution is then implemented in a modern programming language such as Java, C++ or C#.

The assessment should require the candidate to provide either verbal or written evidence stating clearly the scenario within the computer game where the physics simulation is required. The candidate should include an explanation of the physics in the simulation and the mathematical workings for the solution should be included in written/printed form, via e-mail or submitted on digital media.

The solution should be implemented using a modern programming language to create a working physics simulation within a computer game and the code for this should be included in printed form or on digital media.

Higher National Unit specification: statement of standards

Unit title: Game Physics

Unit code: F86H 35

The sections of the Unit stating the Outcomes, Knowledge and/or Skills, and Evidence Requirements are mandatory.

Please refer to *Knowledge and/or Skills for the Unit* and *Evidence Requirements for the Unit* after the Outcomes.

Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the Knowledge and/or Skills section must be taught and available for assessment. Candidates should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion.

Outcome 1

Demonstrate a clear understanding of the physics and associated maths that are used in modern computer games and identify different scenarios in computer games where they are implemented to improve the realism of the simulation

Knowledge and/or Skills

- Knowledge of polar and Cartesian coordinate systems for storing positions and an understanding of vectors for representing positions in 2D and 3D
- How to use trigonometry to calculate the position and direction of an object after it has been rotated in 2D
- How to use rotation matrices and quaternions to calculate the position and direction of on object that has been rotated in 3D
- An understanding of kinematics and dynamics, including Newton's laws of motions
- An understanding of projectiles
- Knowledge of collision detection and collision response
- Be able to identify different scenarios in computer games where the physics learnt in this Outcome can be implemented to improve the realism of the simulation

Evidence Requirements

Evidence for this Outcome will be produced in response to a representative range of multiple-choice questions to assess the candidate's knowledge and understanding of all the Knowledge and/or Skill items listed above. Evidence for all the Knowledge and/or Skills in this Outcome will be accessed using a representative sample of 40 multiple-choice questions. All topics must be covered, however not every sub-topic must be included.

Assessment Guidelines

Assessment must be undertaken in supervised conditions and is closed book. Candidates may not bring to the assessment event any notes, textbooks, handouts or other material (calculators are allowed). The questions presented must change on **each** assessment occasion and the assessment should normally be completed within **2 hours**.

Candidates should answer at least **60%** of the questions correctly.

Higher National Unit specification: statement of standards

Unit title: Game Physics

If a centre is presenting this assessment on-line the following assessment methods, where appropriate, may be selected:

- Multiple-choice
- Drag and drop
- Multiple response
- Mix and match
- A combination of the above

Outcome 2

Create a solution for a realistic physics simulation by applying physics for a chosen scenario within a computer game

Knowledge and/or Skills

- Be able to use Polar coordinates, Cartesian coordinates or Vectors in either 2D or 3D to store the positions of objects
- Apply trigonometry to calculate the position and direction of an object after it has been rotated in 2D or using rotation matrices and quaternions after it has been rotated in 3D
- Apply kinematics and dynamics, including Newton's laws of motions, on a moving object or objects
- Calculate the paths of projectiles by accurately using physics
- Calculate collision detection and collision response to moving objects using physics

Evidence Requirements

Candidates will need to provide evidence to demonstrate their Knowledge and/or Skills by showing that they can:

- choose an appropriate scenario within a computer game where a realistic physics simulation can be applied.
- explain the scenario and how physics can be applied to it.
- demonstrate a working solution for the scenario by applying physics and maths. Evidence for this should be submitted in written / printed or electronic form.
- a minimum of three topics from the knowledge and/or skills section must be implemented in this assessment.

Assessment Guidelines

Assessment should be open book under supervised conditions. The evidence for this assessment should include a solution involving physics and maths to a scenario within a computer game where a real-time physics simulation is required.

The assessment should require the candidate to provide either verbal or written evidence stating clearly the scenario within the computer game where the physics simulation is required. The candidate should include an explanation of the physics in the simulation and the mathematical workings for the solution. This should be submitted in written / printed form, e-mail or digital media.

Higher National Unit specification: statement of standards (cont)

Unit title: Game Physics

A **minimum of three topics from those listed in the Knowledge and/or Skills section** must be represented in the solution to the physics simulation. This does not meant that everything covered in each of the three chosen topics must be implemented in the solution, but at least one sub-topic from each of the three separate topics must be present in the solution.

Outcome 3

Implement game physics by coding a physics simulation in a modern programming language for a chosen scenario within a computer game

Knowledge and/or Skills

- Be able to use Polar coordinates, Cartesian coordinates or Vectors in either 2D or 3D within code to store the positions of objects within a game
- Apply trigonometry in code for a game to calculate the position and direction of an object after it has been rotated in 2D or by using rotation matrices and quaternions after it has been rotated in 3D
- Apply kinematics and dynamics in code for a game, including Newton's laws of motions, on a moving object or objects
- Implement projectiles in code by accurately calculating the path of projectiles within a game
- Apply collision detection and collision response to moving objects within the code for a game

Evidence Requirements

Candidates will need to provide evidence to demonstrate their Knowledge and/or Skills by showing that they can:

- choose an appropriate scenario within a computer game where a realistic physics simulation can be applied.
- the physics simulation should be implemented in a modern programming language such as Java, C++ or C#. The code for the simulation should be submitted in printed form or electronically on digital media.
- a minimum of three topics from the knowledge and/or skills section must be implemented in this assessment.

Assessment Guidelines

Assessment should be open book under supervised conditions. The evidence for this assessment is the implementation of a real time physics simulation within a computer game using a modern programming language such as Java, C++ or C#. The code for this should be included in printed form or electronically on digital media.

A **minimum of three topics from those listed in the Knowledge and/or Skills section** must be represented in the implementation of the physics simulation. This does not meant that everything covered in each of the three chosen topics must be implemented, but at least one sub-topic from each of the three separate topics must be present in the game code.

Higher National Unit specification: statement of standards (cont)

Unit title: Game Physics

Outcomes 2 and 3 can be integrated into one assessment which will involve problem solving and application of their knowledge of the subject. It will require the candidate to create a solution for a physics simulation within a game and then implement it in a modern programming language, which the candidate should have previous knowledge and experience of.

Administrative Information

Unit code: F86H 35

Unit title: Game Physics

Superclass category: RC

Original date of publication: August 2009

Version: 01

History of changes:

Version	Description of change	Date

Source: SQA

SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of Higher National qualifications.

Additional copies of this Unit specification can be purchased from the Scottish Qualifications Authority. Please contact the Customer Contact Centre for further details, telephone 0845 279 1000.

Higher National Unit specification: support notes

Unit title: Game Physics

This part of the Unit specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 80 hours.

Guidance on the content and context for this Unit

This Unit has been developed to form part of the HND Computer Games Development award and is suitable for candidates who are proposing to follow a career in the games industry, although the topics covered would also be applicable to candidates looking for a job in computer animation. It is anticipated that the Unit would be delivered in the second year of the award if traditional delivery schedules are being observed.

The most appropriate approach to delivery within the Group Award is to implement the physics simulation described in Outcomes 2 and 3 within a computer game developed as evidence of assessment for one of the programming Units in the award. This would allow for a degree of cross assessment between Outcome 3 and an appropriate programming Unit.

It is recommended that candidates should possess Higher Physics or Higher Maths or equivalent HN Units before attempting this Unit. Candidates should also have some experience of at least one high level programming language such as C++, Java or C#.

The idea of this Unit is to provide students with the necessary knowledge and skills required to implement realistic real-time physics simulations into computer games and as such it should assist the candidates in their efforts to create games which respond realistically to their simulated environments, in the programming Units in the Group Award.

Guidance on the delivery and assessment of this Unit

It is anticipated that the knowledge and/or skills that the candidates are expected to gain from this Unit, will need to be covered completely before the candidate can attempt the assessments for Outcome 1, 2 and 3. Therefore the knowledge of the physics and associated maths for all the topics in the Unit should be learnt and the applied physics and mathematical skills needed to create physics simulations in computer games should be fully understood before attempting the Outcomes.

Delivery

This Unit could be delivered on a daily, weekly or bi-weekly basis at the discretion of the centre. A typical delivery pattern for the Unit might be:

Higher National Unit specification: support notes (cont)

Unit title: Game Physics

Topic 1 (2 hours) — Introduction — Why are Physics relevant to games development?

- How are Physics involved in the creation of a computer game?
  - Real-time physics in game engines.
- Look at and identify where Physics have been used in current games, mentioning some of the topics what will be coming up such as Newton's Laws, rotational matrices.
- Differences between 2D and 3D in creating a real time physic model in a game.
  - 2D objects: height, width, area, position (corner of object or centre of object), rotation.
  - 3D primitives: circular cylinders, rectangular cylinders, spheres. Look at the difference properties of these primitives such as radius, diameter, circumference, height, width, area.
  - Bounding spheres versus bounding boxes for collision detection.

Topic 2 (6 hours) — Position

- Look at how we store position (2D versus 3D):
  - Polar coordinates versus Cartesian coordinate system.
  - Vectors: representing positions in 2D and 3D space using vectors.
  - Scalar and Vector multiplication.
  - Vector addition and subtraction.

Suggested exercises to apply Knowledge/Skills (Using a language such as C++, C# or Java)

Use vectors to store 2D positions of an object (such as an overhead 2D view of a car sprite) and to move that object by multiplying or adding to the vector. Repeat this for a 3D object.

Topic 3 (12 hours) — Rotation in 2D versus 3D

- 2D Rotation using trigonometry. Learn how to calculate the new direction and position after rotation of an object, taking into account the point which the object is rotated around.
- 3D Rotation using Linear Algebra.
  - Using rotation matrices and quaternions to calculate direction and position after rotation.

Suggested exercises to apply Knowledge/Skills (Using a language such as C++, C# or Java)

Apply rotation to a 2D object in a computer simulation and move that object in the new direction it is pointing in, applying the maths learnt in this topic. Repeat this for a 3D object.

Higher National Unit specification: support notes (cont)

Unit title: Game Physics

Topic 4 (20 hours) — Kinematics and Dynamics

- Speed, distance, displacement, velocity, acceleration — describe what they are in detail and how to calculate them.
- Look at the three basic types of rigid bodies: single particles, particle systems and continuums of mass.
- Look at the properties of Mass — Mass, centre of mass, moment of inertia.
- Study Newton's three laws of Motion.
- Look at different types of forces with reference to Newton's laws and how to calculate them and apply them:
  - Gravitational Forces
  - Spring Forces
  - Friction and other dissipative forces
  - Torque
  - Other external forces.
- Linear motion and rotational motion.
- Rigid body motion — Newtonian Dynamics.
- Ragdoll physics — where a ragdoll is a collection of multiple rigid bodies tied together by a skeletal system that restricts how the bones may move relative to each other.
- Study the effects of pressure, elasticity, stress and strain. Look at how to calculate these and the effects on the objects they are applied to.

Suggested exercises to apply Knowledge/Skills (Using a language such as C++, C# or Java)

Apply some of the main principles learnt in this topic (velocity, acceleration, motion, gravity, external forces) to a computer simulation in 2D or 3D. Take into account the environment, whether it is a space craft travelling through space with no resistance or a car travelling along a road with friction acting on it.

Topic 5 (12 hours) — Projectiles

- Look at examples such as a bullet fired from a gun or a cannon ball fired from a canon and how different forces act on them.
- Learn how to calculate displacement (distance travelled), position, acceleration and velocity of a projectile, taking into account gravity, wind resistance etc.

Suggested exercises to apply Knowledge/Skills (Using a language such as C++, C# or Java)

Build a 2D or 3D computer simulation, using projectiles, for a relevant subject such as a bullet being fired from a gun, a ball being kicked into the air in a soccer game or a ball being thrown by a pitcher in baseball.

Higher National Unit specification: support notes (cont)

Unit title: Game Physics

Topic 6 (12 hours) — Collision detection and response

- Collision detection in a computer simulation – bounding boxes, bounding spheres, pixel by pixel.
- How do objects respond to collisions?
  - — Linear collision response: linear impulse and momentum.
  - — Angular collision response: angular impulse and momentum.
  - — Collisions between objects and immovable objects (such as a wall).

Suggested exercises to apply Knowledge/Skills (Using a language such as C++, C# or Java)

Build a computer simulation in 2D or 3D where two objects may collide into each other. Implement collision detection into the simulation and add in appropriate collision responses when a collision occurs.

Assessment

Outcome 1

This Outcome should be assessed by a single closed book multiple-choice test, consisting of 40 questions which sample the topics listed above. The test must contain questions from each topic, but does not need to contain questions on every sub-topic listed above.

Candidates should complete the test within 2 hours and should answer at least **60%** of the questions correctly.

Outcome 2

Outcomes 2 and 3 can be assessed using separate assessments or in one integrated assessment which will involve problem solving and application of their knowledge of the subject.

The assessment for Outcome 2 should be open book under supervised conditions. The time allocated to the assessment for Outcome 2 will be at the discretion of the centre, but should take roughly 6 hours and certainly no more than 12 hours.

A minimum of three topics from those listed should be implemented in the assessment, although not every sub-topic from the chosen topics must be demonstrated within the solution.

The assessment requires the candidate to report back, providing evidence either verbally or written stating clearly the scenario within the computer game where the physics simulation is required. This should include an explanation of the physics and maths in the simulation.

The mathematical workings for the solution should be submitted in written/printed form, although it could also be submitted electronically if it can be implemented in a maths package, which could then be submitted via e-mail or on digital media.

It should be noted that an approximation of the real world physics used in the chosen scenario would be acceptable in certain cases, as long as the approximation of the physics still provides a realistic physics simulation within the game.

Higher National Unit specification: support notes

Unit title: Game Physics

Outcome 3

Outcomes 2 and 3 can be assessed using separate assessments or in one integrated assessment which will involve problem solving and application of their knowledge of the subject.

The assessment for Outcome 3 should be open book under supervised conditions. The time allocated to the assessment for Outcome 3 will be at the discretion of the centre, but should take roughly 6 hours and certainly no more than 12 hours.

A minimum of three topics from those listed should be implemented in the assessment, although not every sub-topic from the chosen topics must be demonstrated within the solution.

The implementation should be in the form of a physics simulation within a computer game, which should be coded using a modern programming language of the candidate's choice, although the centre may wish to specify the language they are to use. The code created to implement the physics simulation, should be printed and submitted as evidence of assessment. Alternatively the code could be submitted on digital media as part of a computer program.

It should be noted that an approximation of the real world physics used in the chosen scenario would be acceptable in certain cases, as long as the approximation of the physics still provides a realistic physics simulation within the game.

The most appropriate approach to delivery within the Group Award is to implement the physics simulation described in Outcome 3 within a computer game developed as evidence of assessment for one of the programming Units in the award. This would allow for a degree of cross assessment between Outcome 3 and an appropriate programming Unit. The time spent on this assessment will depend a lot on the level of cross assessment that the candidate is allowed.

Opportunities for developing Core Skills

The achievement of this Unit gives automatic certification of the following:

- Critical Thinking at SCQF level 6
- *Numeracy* at SCQF level 6

Candidates meet the Critical Thinking Core Skill component through identifying a scenario within a computer game that requires a physics simulation, then creating a solution and finally implementing that solution. The evidence for this will be in the verbal or written report they are required to do for Outcome 2 to explain the scenario and the solution, along with the code they create for Outcome 3, to implement the simulation.

Candidates meet the *Numeracy* Core Skill by applying Maths, involving numerical data, to the physics simulation they are required to create for Outcomes 2 and 3.

Higher National Unit specification: support notes (cont)

Unit title: Game Physics

Open learning

If this Unit is delivered by open or distance learning methods, additional planning and resources may be required for candidate support, assessment and quality assurance. A combination of new and traditional authentication tools may have to be devised for assessment and re-assessment purposes.

Disabled candidates and/or those with additional support needs

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering whether any reasonable adjustments may be required. Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements**

General information for candidates

Unit title: Game Physics

In this Unit you will acquire the knowledge and skills required to implement real world physics, as realistically as possible, into real-time physics simulations within a computer game.

On completion of the Unit you should be able to:

1 Demonstrate a clear understanding of the physics and associated maths that are used in modern computer games and identify different scenarios in computer games where they are implemented to improve the realism of the simulation.
2 Create a solution for a realistic physics simulation by applying physics for a chosen scenario within a computer game.
3 Implement game physics by coding a physics simulation in a modern programming language for a chosen scenario within a computer game.

Before attempting this Unit, it is recommended that you should have some prior knowledge of Maths and Physics. A Higher in Physics or Maths or equivalent HN Units is expected. You should also have some experience of at least one high level programming language such as C++, Java or C#.

However since this Unit will usually be delivered as part of the HND Group Award in Computer Games Development, if you have no programming experience, this skill may be obtained from other Units in the award.