



**LIMERICK INSTITUTE
OF TECHNOLOGY**
**INSTITIÚID TEICNEOLAÍOCHTA
LUIMNIGH**

LIMERICK INSTITUTE OF TECHNOLOGY

WINTER EXAMINATIONS 2018/2019

MODULE: GADV08001-Game Physics

PROGRAMME(S):
LC_KGDVM_KTH Bachelor of Science (Honours) Games Design and Development

YEAR OF STUDY: 4

EXAMINER(S):
Eugene Kenny (Internal)
Mr. Damien Costello (External)

TIME ALLOWED: 2 HOURS

INSTRUCTIONS: Answer 4 questions. All questions carry equal marks.

PLEASE DO NOT TURN OVER THIS PAGE UNTIL YOU ARE INSTRUCTED TO DO SO.

The use of programmable or text storing calculators is expressly forbidden.

Please note that where a candidate answers more than the required number of questions, the examiner will mark all questions attempted and then select the highest scoring ones.

Requirements for this paper:

1. Calculators

QUESTION 1**[25 Marks]**

- (a) Suppose a NPC police officer sets up a speed trap on a straight section of a road. He times a player who covered 400 meters in 14 seconds. If the speed limit on that section is 90 *km/h*, will the player get a speeding ticket? **[10 marks]**

Suppose another player is driving a car and suddenly has to break. He is going at 60 *km/h* and the car can decelerate at a rate of -5.55 *m/s*. How much time does the player need to stop?

- (b) A ship's canon shoots a cannonball at a speed of 100 *m/s* at a gross angle (including the ship's roll) of 20 degrees to the horizontal at an enemy ship that is 250 *m* away. The height of the launch canon is 10 *m* above sea level. **[15 marks]**

The enemy ship can be approximated by a rectangular volume that is 20m high by 40m long by 12m deep. Will the cannonball hit its target?

QUESTION 2**[25 Marks]**

- (a) Why is it necessary to use numerical methods to solve certain physics equation? Name, describe and compare two techniques that are used to solve certain equations numerically. **[10 marks]**
- (b) For a time dependent variable, $x(t)$, satisfying the equation: **[15 marks]**

$$x(t) = 100t - 2t^2$$

and with $x = 0$ at $t = 0$ show how you would solve for x using the techniques you have described above.

QUESTION 3**[25 Marks]**

- (a) What do the terms *broad-phase*, *mid-phase* and *narrow-phase* mean in the context of collisions detection systems for computer games. **[10 marks]**
- (b) Outline the *Gilbert–Johnson–Keerthi* (GJK) distance algorithm and show how it can be used to detect if a collision has occurred between two convex objects. **[15 marks]**

QUESTION 4**[25 Marks]**

- (a) Discuss the problem of how best to represent rigid bodies for the purpose of collision detection and describe the different approaches that may be taken to solve it. **[10 marks]**
- (b) When your game program detects penetration of one rigid body object by another what technique would you use to work out the time of the actual collision? **[10 marks]**
- (c) One unwelcome effect in modelling bodies that may collide is tunnelling. What does this refer to, why does it happen and how can it be avoided? **[5 marks]**

QUESTION 5**[25 Marks]**

- (a) Describe a physics model that is sometimes used to represent cloth and other soft bodies. **[10 marks]**
- (b) What in your opinion are the advantages and disadvantages of writing your own physics engine as compared to using a commercial one? **[15 marks]**

Useful Formulas

Equations of linear motion:

$$\begin{aligned}v(t + \Delta t) &= v(t) + a\Delta t \\ \bar{v} &= (v(t + \Delta t) + v(t))/2 \\ \Delta p_0 &= \frac{1}{2}(v(t + \Delta t) + v(t))\Delta t \\ \Delta p_0 &= v(t)\Delta t + \frac{1}{2}a\Delta t^2 \\ v(t + \Delta t)^2 &= v(t)^2 + 2a\Delta p_0\end{aligned}$$

Newton's Second Law:

$$F_{net} = m \cdot a$$

Static and kinetic friction

$$F_s = \mu_s \cdot F_N \text{ and } F_k = \mu_k \cdot F_N$$

Equations of angular motion:

$$\begin{aligned}\omega(t + \Delta t) &= \omega(t) + \alpha\Delta t \\ \bar{\omega} &= (\omega(t + \Delta t) + \omega(t))/2 \\ \Delta\theta &= \frac{1}{2}(\omega(t + \Delta t) + \omega(t))\Delta t \\ \Delta\theta &= \omega(t)\Delta t + \frac{1}{2}\alpha\Delta t^2 \\ \omega(t + \Delta t)^2 &= \omega(t)^2 + 2\alpha\Delta\theta\end{aligned}$$

Coefficient of restitution:

$$C_R = -\frac{v_{A+} - v_{B+} \cdot n}{v_{A-} - v_{B-} \cdot n}$$

Collision impulse (without rotation):

$$j = -(1 + C_r)(v_{A-} - v_{B-}) \cdot n / \left(\frac{1}{m_A} + \frac{1}{m_B}\right)$$

Linear velocity resolution:

$$v_+ = v_- + \frac{j}{m}n$$

Angular velocity resolution:

$$\omega_+ = \omega_- + I^{-1}(r \cdot (j \cdot n))$$