LIMERICK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA LUIMNIGH

LIMERICK INSTITUTE OF TECHNOLOGY

WINTER EXAMINATIONS 2019/2020

Friday 6th December 2019, 9.30 AM – 11.30 AM

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? **[5 marks]**

(b) 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? **[5 marks]**

(c) 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 collision 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:	$v(t+\Delta t) = v(t) + a\Delta t$ $\bar{v} = (v(t+\Delta t) + v(t))/2$ $\Delta p_0 = \frac{1}{2}(v(t+\Delta t) + v(t))\Delta t$ $\Delta p_0 = v(t)\Delta t + \frac{1}{2}a\Delta t^2$ $v(t+\Delta t)^2 = v(t)^2 + 2a\Delta p_0$
Newton's Second Law:	$F_{net} = m \cdot a$
Static and kinetic friction	$F_s = \mu_s \cdot F_N$ and $F_k = \mu_k \cdot F_N$
Equations of angular motion:	$\omega(t+\Delta t) = \omega(t) + \alpha\Delta t$ $\bar{\omega} = (\omega(t+\Delta t) + \omega(t))/2$ $\Delta\theta = \frac{1}{2}(\omega(t+\Delta t) + \omega(t))\Delta t$ $\Delta\theta = \omega(t)\Delta t + \frac{1}{2}\alpha\Delta t^2$ $\omega(t+\Delta t)^2 = \omega(t)^2 + 2\alpha\Delta\theta$
Coefficient of restitution:	$C_R = -\frac{v_{A+} - v_{B+} \cdot n}{v_{A-} - v_{B-} \cdot n}$
Collision impulse (without rotation):	$j = -(1+C_r)(v_{A-} - v_{B-}) \cdot n / (\frac{1}{m_A} + \frac{1}{m_B})$
Linear velocity resolution:	$v_+ = v_- + \frac{j}{m} n$
Angular velocity resolution:	$\omega_+ = \omega_- + I^{-1}(r \cdot (j \cdot n))$