

**OLLSCOIL NA hEIREANN, CORCAIGH**  
THE NATIONAL UNIVERSITY OF IRELAND, CORK

COLAISTE NA hOLLSCOILE, CORCAIGH  
UNIVERSITY COLLEGE, CORK

**SUMMER EXAMINATION 2006**

Process Engineering I  
Civil and Environmental Engineering I  
Microelectronic Engineering I

**PY1007: Physics for Engineers I**

Prof. I. McGovern  
Prof. J. McNerney  
Dr. Th. Busch

*Attempt all three questions availing of the options indicated. If both options of a particular question are answered, please indicate which is to be examined by clearly crossing out the other attempt. The use of non-programmable calculators is permitted.*

**Time allowed: 1.5 hours**

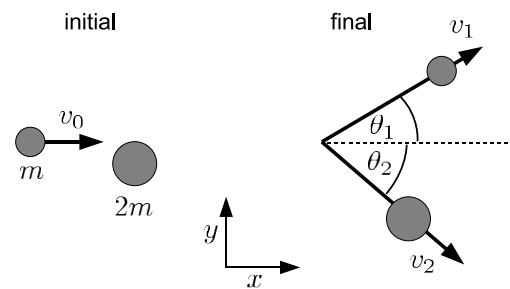
Boltzmann constant:  $k_B = 1.38 \times 10^{-23} \text{ JK}^{-1}$   
gravitational acceleration:  $g = 9.81 \text{ ms}^{-2}$

**Question 1**

- (a) Name three different forms of energy and write down explicit mathematical expressions for the two forms that a point particle in a homogeneous gravitational field with no internal degrees of freedom can possess. [3 marks]
- (b) A basketball player shoots a ball at the basket, which is at a height of 3 m above the floor, from a height of 2 m above the floor. The initial speed of the ball is  $6.7 \text{ ms}^{-1}$  and the angle of the shot is  $45^\circ$ . Neglect air resistance. How far must he be away from the basket to score points? (Note that points are only scored when the ball goes through the net coming from above!) [4 marks]
- (c) What will be the speed of the ball when it reaches the basket? [3 marks]

**OR**

Consider an off-centre collision of an object of mass  $m$  that travels at a velocity  $v_0$  with a second, stationary object of mass  $2m$ . The incoming particle scatters at an angle  $\theta_1 = \cos^{-1}(3\sqrt{2}/5)$  and the originally stationary particle at an angle  $\theta_2$ . The collision is inelastic and exactly half of the incoming kinetic energy is lost in the collision.



- (a) Write down the equations for the conservation of momentum for the  $x$  and the  $y$  direction and the equation relating the kinetic energy in the system before and after the collision (in terms of the velocity) [3 marks]
- (b) Use the expression for the kinetic energy and the equation

$$4v_2^2 = v_0^2 - 2v_0v_1 \cos \theta_1 + v_1^2 \quad (1)$$

to calculate the final velocity of the incoming particle in terms of  $v_0$  only (Do not use your calculator. Leave terms such as  $\sqrt{2}$  as they are!) [4 marks]

- (c) Calculate the final velocity of the target particle in terms of  $v_0$  only. [3 marks]

### Question 2

- (a) A turn in a road, with a radius of curvature  $r = 150$  m, is banked at an angle  $\theta$ , such that at an optimised speed of  $80 \text{ ms}^{-1}$  the friction force is reduced to zero. What is that angle  $\theta$ ? [3 marks]
- (b) Now imagine that on a rainy day the coefficient of static friction between a car's tires and the road is  $\mu_R = 0.5$ . What is the maximum speed  $v_{\text{max}}$  at which the car can take the turn? Be sure to draw a very clear free-body diagram for the car. [4 marks]
- (c) Explain the concept of conservation of energy and what it means in the case of a car driving along a track where the tires experience friction. [3 marks]

OR

- (a) A boy swings a 1.3 kg stone (which is at the end of a 75 cm long string) horizontally around his head. Starting from rest, he accelerates the stone to an angular speed of 0.4 rotations per second in the first 2.0 seconds. What are the tangential velocity, the angular acceleration and the centripetal acceleration of the stone at  $t = 2.0$  s? [4 marks]
- (b) The maximum tension the string can withstand is 11 Newtons. How long can the boy accelerate the stone (starting at  $t = 0$  s) before the string breaks? Use the value of the angular acceleration from the previous question. [3 marks]
- (c) What is the angular momentum of the stone at  $t = 2.0$  s? [3 marks]

### Question 3

- (a) Write down the full expression for a travelling, simple harmonic wave in one-dimension and identify the amplitude, phase, frequency and wavenumber. [4 marks]
- (b) Explain what dispersion is and give the expression for the speed of a travelling wave. [3 marks]
- (c) Explain the superposition principle and give the conditions for total constructive and total destructive interference of two waves. A simple graph to define your variables might be helpful here. [3 marks]

OR

- (a) Write down and explain the First Law of Thermodynamics and explain its physical meaning. [3 marks]
- (b) Calculate the average kinetic energy and the average velocity of a Helium atom in the gas phase at a temperature of 300 K. (mass of a Helium atoms:  $m_{He} = 6.644 \times 10^{-27}$  kg) [4 marks]
- (c) Explain the theorem of equipartition of energy and name all degrees of freedom available to a diatomic molecule. [3 marks]