OLLSCOIL NA hÉIREANN MÁ NUAD

THE NATIONAL UNIVERSITY OF IRELAND MAYNOOTH

BE in Electronic Engineering with Communications
BE in Electronic Engineering with Computers
BE in Electronic Engineering
BSc in Robotics & Intelligent Devices

Year 1

SEMESTER 1
2016 -2017

Physics for Engineers 1
EE 104

(*Prof. J. A. Murphy, Dr. C. O'Sullivan, Dr. N. Trappe*)

Time allowed: 2 hours

Answer ***any four*** questions

All questions carry equal marks

<u>All workings</u> must be clearly shown

Relevant physical constants and data can be found at the end of the paper

MECHANICS

1. (a) Use vector addition to calculate the net displacement of a particle, given that it went through three consecutive displacements represented by

Displacement	Magnitude (m)	Direction
Displacement 1	5	60° north of east
Displacement 2	7	due west
Displacement 3	3	45° south of east

(8 marks)

(b) An object is dropped from a tall building. A second object is thrown downwards with an initial velocity of 25m/s two seconds after the first object was dropped. If both objects hit the ground at the same instant of time, calculate the height of the building. *(9 marks)*

(c) A car is travelling at 60 km/hour on a horizontal road. If the coefficient of friction is 0.1 on a wet day, what is the minimum distance in which the car can stop without skidding? Compare this answer to dry road conditions when the coefficient of friction is 0.6. *(8 marks)*

2. (a) Describe how putting a spin on a football when kicked makes it follow a curved path rather than a straight path. Quote the relevant principle and use a simple diagram of the spinning ball. *(8 marks)*

(b) Taking a model a small cube of water of length h, derive an expression for the static pressure of the water assuming that it is in equilibrium. *(8 marks)*

(c) What is the smallest number of whole wood logs that can be used to build a wooden raft that will support a combined mass of 320 kg? Take the density of water and the wood of the raft to be 1000 kg/m^3 and 725 kg/m^3 and each log to have a volume of 6×10^{-2} m^3. *(9 marks)*

3. (a) Derive the impulse-momentum theory and show how a force applied over time can be written in terms of the change of momentum for a closed system. *(8 marks)*

(b) Show for a closed system that linear momentum is conserved when two objects collide with masses m_1 and m_2 using the impulse-momentum theory. If two identical automobiles have the same speed, one traveling east and one traveling west, do these cars have the same momentum? Explain your answer in referring to vector quantities. *(9 marks)*

(c) A 46 kg skater is standing still on ice beside the ice ring wall. By pushing against the wall she propels herself backward with a velocity of -1.2 m/s. Her hands are in contact with the wall for 0.80 seconds. Calculate the magnitude and direction of the average force she exerts on the wall. *(8 marks)*

4. (a) Explain what is meant by the term *escape velocity*? *(2 marks)*

(b) Calculate the escape velocity of the Earth. *(6 marks)*

(c) Planet A has twice the mass and three-times the radius of Planet B. How does the escape velocity of Planet A compare with that of Planet B? *(9 marks)*

(d) How does the escape velocity influence the range of gases that are found in the Earth's atmosphere? *(8 marks)*

HEAT/PROPERTIES OF MATTER

5. (a) Write a brief description of the three different heat transfer mechanisms and give an example of each. *(8 marks)*

(b) One end of a cylindrical iron poker is placed in a fire where the temperature is 450 °C, and the other end is kept at a temperature of 25 °C. The poker is 0.9 m long and has a radius of 6×10^{-3} m. Calculate the amount of heat conducted from one end of the poker to the other in 10 seconds taking the thermal conductivity of iron to be 79 K/(s.m °C). *(8 marks)*

(c) The filament of a traditional light bulb radiates 60 W of power. If its area and emissivity are 2.7×10^{-5} m^2 and 0.36, calculate the temperature of the bulb filament in this case. *(9 marks)*

6. (a) A simple pendulum is made using a long thin metal wire. When the temperature drops, does the period of the pendulum increase, decrease, or remain the same? Explain your answer using the relevant equations. *(8 marks)*

(b) Two identical mugs contain hot coffee from the same pot. One mug is full, while the other is only one half full. Sitting on the kitchen table, which mug stays warmer longer? Explain your answer in terms of the heat transfer equations. *(8 marks)*

(c) A piece of glass has a temperature of 83.0 °C. Liquid with a temperature of 43.0 °C is poured over the glass, completely covering it, and after a time the temperature at equilibrium reaches 53.0 °C. The mass of the glass and the liquid is the same. Ignoring the container that holds the glass and liquid and assuming that the heat lost to or gained from the surroundings is negligible, calculate the specific heat capacity of the liquid. Take the specific heat capacity for the glass to be 840 J/(kg.°C). *(9 marks)*

FUNDAMENTAL CONSTANTS AND UNITS

Acceleration due to Earth's gravity	g	=	9.80		$m\ s^{-2}$
Alpha particle mass		=	6.69	$\times 10^{-27}$	kg
Atomic mass unit	1 u	=	1.661	$\times 10^{-27}$	kg
		=	931.5		$MeV\ c^{-2}$
Avogadro's number	N_A	=	6.022	$\times 10^{23}$	$(mol)^{-1}$
Bohr magneton	μ_B	=	9.274	$\times 10^{-24}$	$J\ T^{-1}$
Bohr radius	a_o	=	5.292	$\times 10^{-11}$	m
Boltzmann Constant	k_B	=	1.381	$\times 10^{-23}$	$J\ K^{-1}$
Density of water (4 ^{0}C)		=	1.000	$\times 10^{3}$	$kg\ m^{-3}$
Electron mass	m_e	=	9.109	$\times 10^{-31}$	kg
		=	5.486	$\times 10^{-4}$	u
Electron volt	1 eV	=	1.602	$\times 10^{-19}$	J
Elementary charge	e	=	1.602	$\times 10^{-19}$	C
Gas constant	R	=	8.315		$J\ K^{-1}\ (mol)^{-1}$
Gravitational constant	G	=	6.673	$\times 10^{-11}$	$N\ m^2\ kg^{-2}$
Latent heat of fusion of water		=	3.35	$\times 10^{5}$	$J\ kg^{-1}$
Latent heat of fusion of ice		=	33.5	$\times 10^{4}$	Jkg^{-1}
Neutron mass	m_n	=	1.675	$\times 10^{-27}$	kg
		=	1.008 665		u
Permeability of free space	μ_o	=	4π	$\times 10^{-7}$	$T\ m\ A^{-1}$
Permittivity of free space	ε_o	=	8.854	$\times 10^{-12}$	$C^2\ N^{-1}\ m^{-2}$
	$1/(4\pi\varepsilon_o)$	=	8.99	$\times 10^{9}$	$N\ m^2\ C^{-2}$
Planck's constant	h	=	6.626	$\times 10^{-34}$	J s
	$\hbar = h/2\pi$	=	1.055	$\times 10^{-34}$	J s
Proton mass	m_p	=	1.672	$\times 10^{-27}$	kg
		=	1.007 276		u
Rydberg constant	R_∞	=	1.097	$\times 10^{7}$	m^{-1}
Rydberg energy	E_R	=	13.59		eV
Specific heat capacity of ice		=	2000		$Jkg^{-1}K^{-1}$
Specific heat capacity of water		=	4186		$Jkg^{-1}K^{-1}$
Speed of light in vacuum	c	=	2.998	$\times 10^{8}$	$m\ s^{-1}$
Stefan-Boltzmann constant	σ	=	5.670	$\times 10^{-8}$	$J\ s^{-1}\ m^{-2}\ K^{-4}$
Thermal conductivity of glass		=	0.84		$Wm^{-1}K^{-1}$
Thermal conductivity of ice		=	2.2		$J\ s^{-1}\ m^{-1}\ K^{-1}$
Thermal conductivity of insulated wall		=	0.041		$Wm^{-1}K^{-1}$
Wien's constant		=	2.898	$\times 10^{-3}$	m K

ASTRONOMICAL UNITS AND DATA

Astronomical unit	1 A.U.	=	1.496	$\times 10^{11}$	m
Earth's mass	M_E	=	5.974	$\times 10^{24}$	kg
Earth's radius (equatorial)	R_E	=	6.378	$\times 10^{6}$	m
Light year	1 ly	=	9.461	$\times 10^{15}$	m
Parsec	1 pc	=	3.086	$\times 10^{16}$	m
Solar mass	$M_\odot$	=	1.989	$\times 10^{30}$	kg
Solar radius	$R_\odot$	=	6.960	$\times 10^{8}$	m