Maynooth University
National University of Ireland Maynooth

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 - REPEAT
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

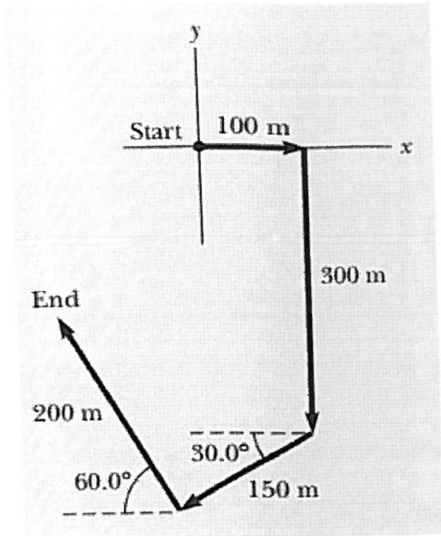
All questions carry equal marks

<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) Distinguish between a vector and a scalar quantity and list an example of each. If a person walks the following four paths, calculate their net displacement (magnitude and direction). *(8 marks)*



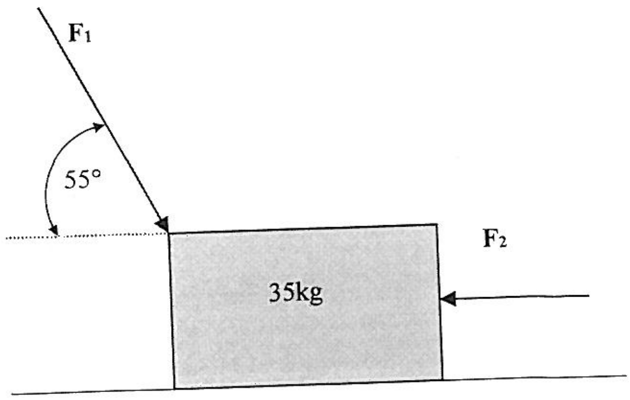
(b) A long jumper in the Olympics leaves the ground at 25° to the horizontal at a speed of 10.0 m/s. How far can he jump? *(9 marks)*

(c) A 6 kg block initially at rest, is pulled along a horizontal surface by a constant horizontal force of 12 N. Calculate the velocity of the block when it has been moved 3 m over the surface by this force when you assume (i) the surface is frictionless, and (ii) when the coefficient of kinetic friction is 0.15. *(8 marks)*

2. (a) State Newton's three laws of motion and give a physical example of a situation where each law applies. *(8 marks)*

(b) A 650 kg elevator moves up from rest for 3 seconds to its cruising speed of 1.75 m/s. Calculate the power required in this 3 second period for the elevator. *(9 marks)*

(c) Two forces, $\boldsymbol{F_1}$ and $\boldsymbol{F_2}$ act on a 35 kg block as in the diagram below. The magnitude of the forces are $\boldsymbol{F_1} = 70.0$ N and $\boldsymbol{F_2} = 40.0$ N. What is the horizontal acceleration of the block (magnitude and direction)? *(8 marks)*



3. (a) Briefly describe Archimedes' Principle and describe the effects of submerging an object in a fluid. Use the example of an iceberg on the ocean to discuss why certain objects float or sink. *(8 marks)*

(b) The density of ice is 917 kg/m^3, and the density of sea water is 1025 kg/m^3. A swimming polar bear climbs onto a piece of floating ice that has a volume of 5.2 m^3. What is the weight of the heaviest bear that the ice can support without sinking completely beneath the water? *(9 marks)*

(c) Briefly outline the main terms in Bernoulli's equation for a moving fluid. Suppose that a 15 m/s wind is blowing across the roof of your house. The density of air is 1.29 kg/m^3. Calculate the reduction in pressure (below atmospheric pressure of stationary air) that accompanies this wind. *(8 marks)*

HEAT/PROPERTIES OF MATTER

4. (a) State the Law of Universal Gravitation. *(3 marks)*

(b) Two planets (A and B) orbit a star. Planet B is three times farther from the star than Planet A is and it has twice the mass of Planet A. If the force from the star on Planet A is x, then what is the force from the star on Planet B? *(10 marks)*

(c) Write a brief account of Cavendish's experiment to measure the gravitational constant. *(12 marks)*

5. (a) What is the latent heat for a substance? Describe the relevant equation for the process and explain latent heat of fusion and vaporisation. *(8 marks)*

(b) Heat is added to a 0.5 kg of water at room temperature (20 °C). How much energy is required to change this water into steam given that the specific heat capacity of water is 4186 J/kg°C, and the latent heat of vaporisation is 22.6×10^5 J/kg? *(9 marks)*

(c) Calculate the amount of energy radiated per second from a human body (37.2 °C) if the skin has an emissivity of 0.7 and the exposed area is 0.35 m^2 and the person is in a room at 8 °C. *(8 marks)*

6. (a) Describe the linear expansion of materials when heat is applied and outline the relevant equation. A simple pendulum consists of a ball connected to one end of a thin brass wire. The period of the pendulum is 2.0000 seconds. The temperature rises by 140 °C, and the length of the wire increases. Determine the period of the heated pendulum with the thermal expansion of brass being 19×10^{-6} °C^{-1}. *(8 marks)*

(b) In filling a bath, how many kilograms of hot water (49.0 °C) must you mix with cold water (13.0 °C) so that the temperature of the bath is 36.0 °C? The total mass of water (hot plus cold) is 191 kg. Ignore any heat flow between the water and its external surroundings.

(9 marks)

(c) How much heat must be added to 0.45 kg of aluminium to change it from a solid at 130 °C to a liquid at 660 °C (its melting point)?
The latent heat of fusion for aluminium is 4.0×10^{5} J/kg, and the specific heat *c* of aluminium is 900 J/kg°C. *(8 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		J$kg^{-1}K^{-1}$
Specific heat capacity of water		=	4186		J$kg^{-1}K^{-1}$
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		W$m^{-1}K^{-1}$
Thermal conductivity of ice		=	2.2		J s^{-1} m^{-1} K^{-1}
Thermal conductivity of insulated wall		=	0.041		W$m^{-1}K^{-1}$
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