UNIVERSITY OF JOHANNESBURG

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

MODULE: **PHYG01A**

GENERAL PHYSICS FOR EARTH SCIENCES

CAMPUS: APK

EXAM: JUNE 2014

DATE: 07/06/2014 **SESSION 12:30 – 15:30**

ASSESSOR: **DR E CARLESCHI**

MODERATOR: **MRS S JACOBS**

DURATION: 160 MINUTES **MARKS: 90**

NUMBER OF PAGES: 3 PAGES (excluding this information page)

INSTRUCTIONS:

1. Answer ALL the questions.
2. Programmable calculators are not permitted.

Question 1 [**14 marks**]

(1.1) Consider the following four vectors: $\vec{A} = -\hat{i} - 3\hat{j}$, $\vec{B} = \frac{3}{2}\hat{i} + 2\hat{j}$, $\vec{C} = \frac{8}{3}\hat{i} - \frac{1}{2}\hat{j}$ and $\vec{D} = -5\hat{i} - \frac{3}{5}\hat{j}$. Calculate both the magnitude and the direction of the following vector: $\vec{R} = +3\vec{A} - 2\vec{B} + 2\vec{C} - \frac{7}{2}\vec{D}$. *[5 marks]*

(1.2) Points P and Q are located on a map and have coordinates $(-3, -1)$ and $(-4, 5)$ respectively, given with respect to the origin of the frame of reference O.
(a) Draw a Cartesian coordinate system, choose a proper unit, and then draw the two *position vectors* for P and Q, i.e. $\overrightarrow{OP}$ and $\overrightarrow{OQ}$. *[2 marks]*
(b) Calculate both the magnitude and the direction of vector $\overrightarrow{PQ}$, and draw it on the diagram above. *[7 marks]*

Question 2 [**16 marks**]

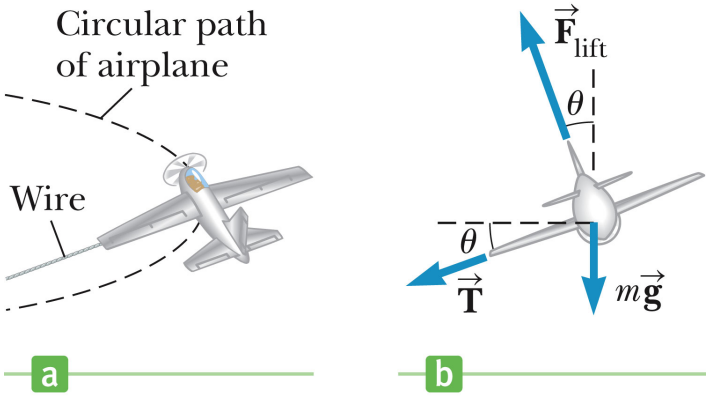
(2.1) A car and a motorcycle both start from rest at the same time on a straight track but the motorcycle is 25.0 m behind the car. The car accelerates at a uniform rate of 3.7 m/s^2 and the motorcycle at a uniform rate of 4.4 m/s^2. Calculate:
(a) how much time elapses before the motorcycle overtakes the car; [*5 marks*]
(b) how far from their starting point each will have travelled during the time calculated in (a). [*3 marks*]

(2.2) A place-kicker must kick a football from a point 36 m from the goal. Half the crowd hopes the ball will clear (i.e. pass above) the crossbar, which is 3.05 m high. When kicked, the ball leaves the ground with a speed of 20 m/s at an angle of 53° with respect to the horizontal.
(a) Calculate by how much the ball clears or falls short of clearing the crossbar. [*6 marks*]
(b) Does the ball approach the cross bar while still rising or while falling? [*2 marks*]

Question 3 [**21 marks**]

(3.1) State Newton's first law of motion. [*2 marks*]

(3.2) A model airplane of mass 0.75 kg flies with a speed of 35 m/s in a horizontal circle at the end of a 60 m control wire as shown in the figure (a) below. The free body diagram of the airplane is shown in figure (b), where $\theta = 20°$ is the angle that the wire makes with the horizontal. Calculate the magnitude of the tension in the wire. [*9 marks*]



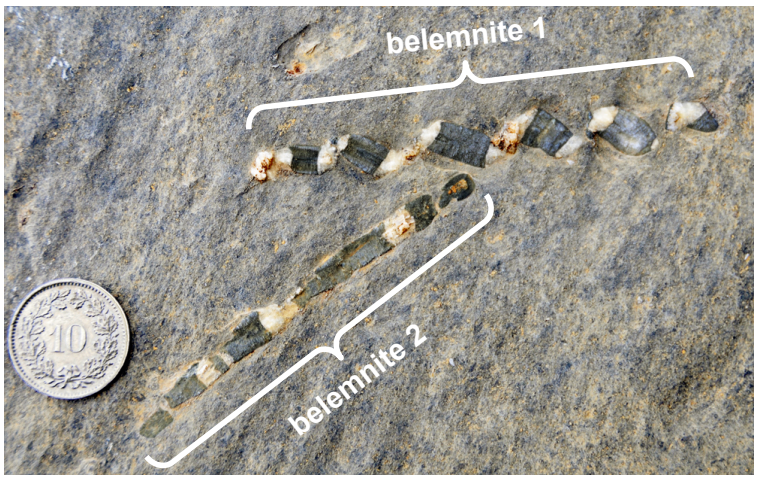
(3.3) **(a)** Explain what is meant by *mass wasting* in physical geography. [*1 mark*]
(b) We can model a rock lying on a slope as a block lying on an incline plane. Three are the factors that can influence the downslope movement of such rock: gravity, friction and rock strength. Discuss in detail how each of them can either favour or prevent the downslope movement of the rock (use a suitable diagram if necessary). [*5 marks*]
(c) Define what is meant by *angle of repose* for a rock on a slope. [*1 mark*]

(3.4) On May 31, 1970, a magnitude 7.7 earthquake triggered a huge debris avalanche on Mt Huascaran in Peru. The moving mass descended from the mountains summit (elevation 6654 m) to the town of Yungay (elevation 2800 m), where it killed an estimated 20 000 people. The length of the run of Mt Huascaran measured on the map to the town is roughly 14.4 km, and the avalanche took about 3 minutes to reach Yungay after its initiation. Calculate the average velocity of this debris avalanche. [*3 marks*]

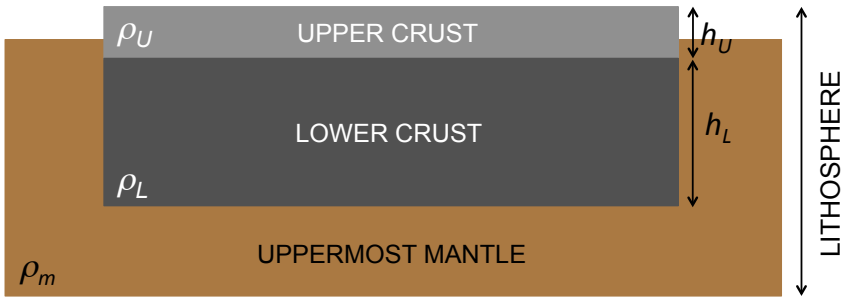
Question 4 [**23 marks**]

(4.1) For safety in climbing, a mountaineer uses a nylon rope that is 50 m long and 1 cm in diameter. When supporting a 90 kg climber, the rope elongates 1.6 m. Calculate its Young's modulus. *[4 marks]*

(4.2) Belemnites are an extinct group of marine cephalopod, similar in many ways to the modern squid. The two belemnites fossils shown in the figure below (found in the Swiss Alps) show that the rock that contains them has been subject to two different kinds of stress: which ones? Elaborate your answer, and use diagrams if it helps to clarify your statements. *[3 marks]*



(4.3) The continental crust (which is divided into upper crust and lower crust) is lying on top of the uppermost mantle. All together they form the continental lithosphere. This layered structure is sketched - not on scale - in the figure below, where the crustal slab has been modelled as an isolated block surrounded on all sides by the lithospheric mantle. The crust is supported by the underlying mantle because of buoyancy, and a portion of the upper crust can emerge.
The structure of the continental crust right next to the Chilean subduction zone looks like the one sketched in the figure below, where $\rho_m = 3320$ kg/m^3, $\rho_L = 2900$ kg/m^3 and $\rho_U = 2800$ kg/m^3 and the densities of the lithospheric mantle, lower and upper crust respectively, and $h_L = 35$ km and $h_U = 15$ km are the thicknesses of the lower and upper crust, respectively.
(a) Draw the free body diagram for the crust. *[1 mark]*
(b) Using Archimedes' principle, calculate the height of the upper crust *above* the mantle level. *[5 marks]*



(4.4) Discuss in your own words the role played by buoyancy at subduction zones. *[2 marks]*

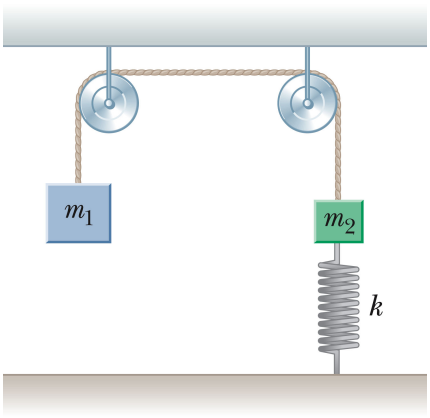
(4.5) The Manila trench, located in the Pacific Ocean close to the Philippines Islands, reaches a depth of 5.4 km. Assuming an average density of the sea water of 1.03×10^3 kg/m^3 and an atmospheric pressure of 1.013×10^5 Pa at the water level, calculate the pressure at that depth. *[4 marks]*

(4.6) (a) Describe the forces acting on the lithosphere which cause the lithospheric flexure at a subduction zone. *[2 marks]*
(b) Draw the bathymetric profile of a typical subduction zone, and explain all its salient features. *[2 marks]*

Question 5 [16 marks]

(5.1) Write down the formal definition for a *conservative force*, and give at least one example for it. [*2 marks*]

(5.2) Two blocks are connected by a light string that passes over two frictionless pulleys as shown in the figure below. They are initially located at the same height from the ground, and $m_1 = 10$ kg while $m_2 = 7$ kg. The block of mass m_2 is attached to a spring of force constant $k = 1000$ N/m. The system is released from rest, and the spring is initially not stretched or compressed.
Apply the conservation of mechanical energy in order to calculate the elongation of the spring. *[5 marks]*



(5.3) The average distance separating the Earth and the Moon is 384×10^3 km. Calculate the net gravitational force exerted by the Earth and the Moon on a spaceship of mass 3×10^4 kg located halfway between them. [*5 marks*]
(GIVEN: $G = 6.67 \times 10^{-11}$ N·m^2/kg^2, mass of the Earth: 5.98×10^{24} kg, mass of the Moon: 7.36×10^{22} kg)

(5.4) (a) Explain what is meant by gravity anomaly. *[1 mark]*
(b) Imagine to be a geologist carrying out a gravity survey, and you suddenly detect a positive gravity anomaly of the order of 10 mGal (i.e. you detect an increase in gravity of the order of that amount). What can you infer from this measurement about the rocks in that region? Elaborate your answer. [*3 marks*]

END of QUESTION PAPER