SURNAME:_______________________________ **INITIALS** _____

STUDENT NUMBER:__________________________________

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

MODULE: **PHYE0A2**

CAMPUS **APK**

EXAM **09 June 2017**

	Student's Mark	Question's Mark
Q 1		15
Q 2		10
Q 3		20
Q 4		10
Q 5		15
Q 6		20
Total		90

EXAMINERS
Dr. D. Britz

MODERATOR
Prof. H. Winkler

DURATION 150 min **MARKS 90**

THIS PAPER CONSISTS OF 20 PAGES INCLUDING THE COVER PAGE

INSTRUCTIONS: **Answer ALL questions IN SPACES PROVIDED**
NO PENCIL

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Question 1 [14]

1.1) Using the kinematic definitions as your point of departure, derive the below expression governing the displacement of a particle under constant acceleration as a function of time. Indicate all relevant arguments in your derivation

$$\Delta x = v_{x,i}t + 1/2(a_x t^2)$$

[4]

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1.2) Starting from the definition of inertia show how this leads to the conservation of linear momentum in a closed system.

[3]

1.3) A person on a bicycle moves along a straight road from his front gate to the shops at a constant speed of 8 m/s. At the shops he then realises that he forgot his wallet at home and races back to fetch it, travelling at a constant speed of 15 m/s. What is his average speed for the journey to the shop and back? What is his average velocity for the same journey?

[3]

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1.4) The x-component of the velocity of a car changes from -2 m/s $\hat{x}$ to +5 m/s $\hat{x}$ in 5 seconds, find:

(a) Is the car travelling in the positive or negative x direction? **[1]**

(b) Does Δv point in the positive or negative x direction? **[1]**

(c) Is the x component of the acceleration positive or negative? **[1]**

(d) Is the car speeding up, slowing down or both? **[1]**

Question 2 [16]

2.1) Show that near the earth's surface the conservation of total mechanical energy holds for an object moved through an arbitrary vertical distance.

[4]

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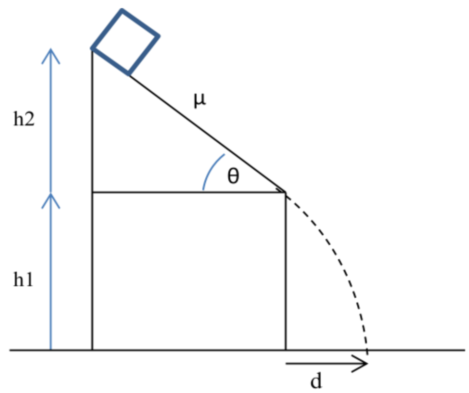
2.2) A block of mass m is at rest at the top of an incline (angle θ measured with respect to the horizontal) shown in the figure below. The surface of the incline is rough with a coefficient of friction μ.

(a) Using conservation of energy find the speed of the block m at the bottom of the incline. **[2]**



(b) With what speed does the mass hit the ground? **[2]**

(c) How far away from the end of the incline does the block land (the magnitude of d)? **[3]**

2.3) Two 1 kg carts are joined together and are initially moving to the right at 2 m/s on a horizontal frictionless track. The join contains explosives which can be detonated remotely. The explosion creates 18 J of energy, half of which is transformed into internal energy (noise, heat *etc.*). The remaining energy pushes the carts apart. What are the velocities of the two carts after the explosion?

[5]

QUESTION 3 [23]

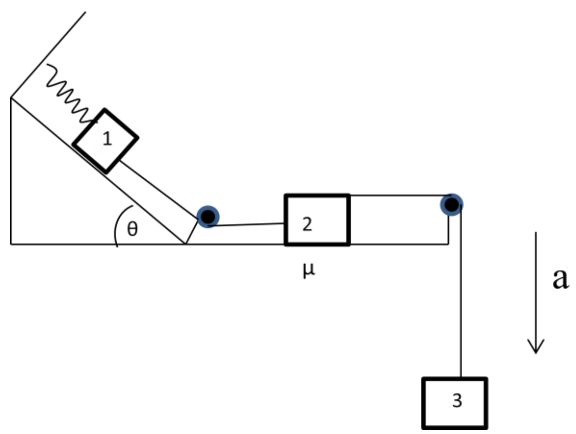
3.1) Starting with the idea that a change in an object's momentum with respect to time is caused by the vector sum of all forces acting on the object, derive:

$$\sum \boldsymbol{F} = m\boldsymbol{a}$$

[3]

3.2) Three masses are connected as shown in the figure below. The direction of the acceleration of mass 3 is shown. The rope connecting the masses is inelastic and the pulleys have no mass and are frictionless. Mass 2 is on a rough surface with a coefficient of friction μ. When the spring connected to mass 1 has been stretched a distance d from its equilibrium position (not stretched), what is the acceleration of the system?

[6]



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3.3) Show that the work done by a non-dissipative, ***spatially dependent*** force is given by:

$$W = \int_{xi}^{xf} F_x dx$$

[4]

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3.4) Use the equation in (3.3) to show that the work done by a spring is:

$$W = \frac{1}{2}k(x_f^2 - x_i^2)$$

[3]

3.5) Show that the maximum height reached by a projectile having an initial velocity $\boldsymbol{v}_i$ launched at an angle θ with respect to the horizontal, is given by:

$$h = \frac{v_i^2(\sin\theta)^2}{2g}$$

[4]

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3.6) A disk P (inertia = 0.4 kg) moves with an unknown velocity along a smooth horizontal surface and collides with a disk Q (inertia = 0.7 kg) which is at rest. After the collision the two slightly deformed disks move apart (without spinning) with the following velocities: P:$v_f = 1.4\cos(20^o)\,\hat{x} + 1.4\sin(20^o)\,\hat{y}$ and Q:$v_f = 0.96\cos(50^o)\,\hat{x} - 0.96\sin(50^o)\,\hat{y}$.

(a) What is the inertial velocity of disk P? **[3]**

QUESTION 4 [23]

4.1) Derive the expression for centripetal acceleration (*i.e.* $a_c = {v^2}/{r}$), stating clearly the logic used.

[4]

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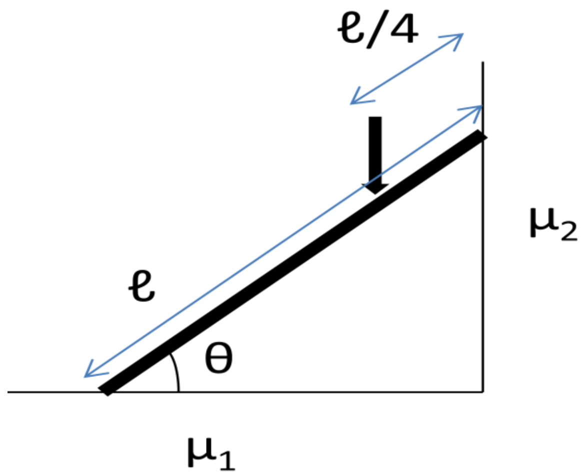
4.2) Derive an expression for the torque applied to a point-like object, with respect to the particle's rotational acceleration. Show all appropriate figures.

[4]

4.3) The figure below represents a ladder (length ℓ) which is leaning on a wall at an angle θ with respect to the floor. The vertical arrow located at a distance ℓ/4 from the top of the ladder represents the location of a man, whose inertia is 80 kg. If the floor and the wall have different coefficients of friction (μ_1 and μ_2), what is the maximum angle θ at which the ladder will not slip?

[6]



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4.4) The tub of a washing machine undergoes a spin cycle, starting from rest and gaining angular speed at a constant rate for 8 s. After these 8 s the angular speed is 5 rev/s. Load-shedding occurs at this point and the tub smoothly slows down to rest in 12 s. How many revolutions does the tub go through since starting?

[3]

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4.4) A 70 kg woman is standing on the edge of a stationary circular turntable whose radius is 3 m. The turntable has an inertia of 400 $kg.m^2$. If the woman walks at a linear speed of 3 m/s in a clockwise direction, find the angular speed of the turntable.

[3]

4.5) State Kepler's laws of planetary motion. **[3]**

Question 5 [17]

5.1) Give the general solution for the displacement of a particle undergoing simple harmonic motion and derive the expressions for its velocity and acceleration.

[2]

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5.2) A travelling wave is described by $f_1(x,t) = A\sin(kx - \omega t)$ when moving to the right. If a wave with the same wavelength and frequency is approaching from the left then find:

(a) The equation of this wave travelling to the left **[1]**

(b) Show how this combination produces standing waves and find the condition for the location of the nodes. You may use the following:
$\sin\alpha + \sin\beta = 2\sin\left(\frac{\alpha+\beta}{2}\right)\cos\left(\frac{\alpha-\beta}{2}\right)$ **[4]**

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5.4) (a) For a non-compressible fluid with a laminar flow, derive the expression for the conservation of matter, the so called “continuity equation”.

[3]

(b) Derive Bernoulli’s equation including a sketch, stating the logic behind each and every step.

[7]

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Question 6 [18]

6.1) (a) What is the period of a simple pendulum on the moon if the length of the string is 0.5 m? Given: moon mass = 7.3×10^{22}kg and moon radius = 1.74×10^{6}m

[2]

(b) How does this compare to the period of this pendulum on the earth? **[1]**

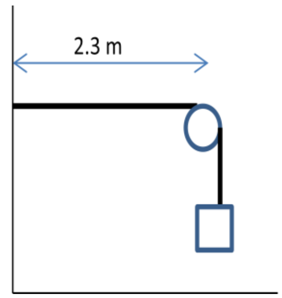
6.2) A geosynchronous orbit implies that a satellite remains at a fixed point above the earth's surface at all times as the earth rotates. Show that the height required to achieve this is

$$(r_e + h)^3 = Gm_e\left(\frac{T}{2\pi}\right)^2$$

[4]

6.2) A cord runs over a massless pulley which is 2.3 m away from the wall. One end of the cord is attached to a wall, while the other end is connected to a mass, as in the figure below. The cord has a mass per unit length $\mu = 1.3$ g/m. What is the mass of the block if the third harmonic of the cord (standing wave) vibrates with a frequency of 550 Hz?

[3]



6.3) A pipe with an inner diameter of 15 mm carries water with a flow rate of 750 mm/s. The inner diameter then narrows from 15 mm to 10 mm. Ignore the viscosity of the water. Find the pressure difference between the 10 and 15 mm diameter pipes.

[4]

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6.4) Two speakers simultaneously emit a note of wavelength λ. The speakers are separated by a distance of $10\lambda/3$ m. If a microphone is moved along the line between the speakers' centres, at what positions will the microphone detect a maximum and minimum in the sound intensity?

[4]

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