Surname and Initial:____________________________

Student Number:______________________________

FACULTY OF SCIENCE
FAKULTEIT NATUURWETENSKAPPE

DEPARTMENT OF PHYSICS
DEPARTEMENT FISIKA
(APK)

MODULE: PHYE0A1/PHY1A01: Engineering Physics

June Exam

DATE: June 2019

EXAMINER: Dr. C.J. Sheppard
Prof. A.R.E. Prinsloo

MODERATOR: Dr. P. Mohanty
Mr P. Molefe

TIME: 150 min – to be allocated at your own discretion and on your own responsibility.
MARKS: 125

INSTRUCTIONS:

1. This is a fill in paper.
2. Write with black or blue pen. Write neatly.
3. **No pencil answer will be accepted**.
4. If a section is rough work indicate as such.
5. Answer **all** questions.
6. This paper consists of 19 pages with 9 questions.
7. Programmable calculators are not allowed.
8. Remember, explanations also count marks.
9. In all answers keep in mind that this is a calculus based course. Marks will be allocated accordingly.
10. 2.5 Hours in total - to be distributed at your own discretion and on your own responsibility between the various questions.

Question		**Mark**
1	20	
2	10	
3	20	
4	8	
5	14	
6	14	
7	16	
8	15	
9	8	
Total/	**125**	

<u>Question 1</u> [20]

<u>Instructions:</u>

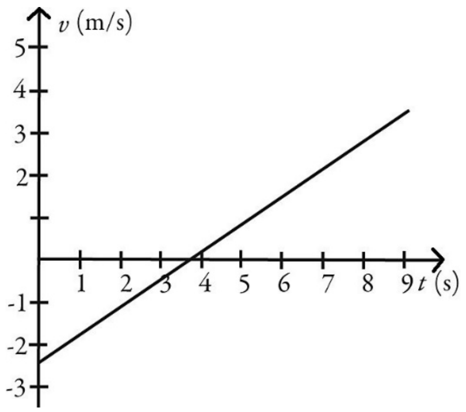
This is a multiple choice question. Indicate your answer by <u>underlining</u> and circling the correct answer. <u>No pencil</u> answers will be accepted. ***Each question counts two marks*****.**

1.1 If the eastward component of vector $\vec{A}$ is equal to the westward component of vector $\vec{B}$ and their northward components are equal. Which one of the following statements about these two vectors is correct? Are B and D possible correct questions?

A) Vector $\vec{A}$ is parallel to vector $\vec{B}$.
B) Vectors $\vec{A}$ and $\vec{B}$ point in opposite directions.
C) Vector $\vec{A}$ is perpendicular to vector $\vec{B}$.
D) The magnitude of vector $\vec{A}$ is equal to the magnitude of vector $\vec{B}$.
E) The magnitude of vector $\vec{A}$ is twice the magnitude of vector $\vec{B}$.

1.2 The motion of a particle is described in the velocity as function of time graph shown in the figure. We can say that its speed:

A) increases.
B) decreases.
C) increases and then decreases.
D) decreases and then increases.
E) None of the above

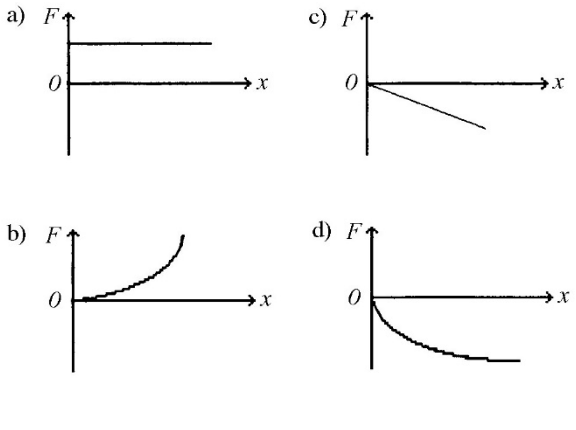


1.3 The following four forces act on a 4.00 kg object: $\vec{F}_1$ = 300 N east, $\vec{F}_2$ = 700 N north, $\vec{F}_3$ = 500 N west and $\vec{F}_4$ = 600 N south. What is the acceleration of the object?

A) 224 N in a direction 63.4° north of west
B) 300 N in a direction 63.4° north of west
C) 224 N in a direction 26.6° north of west
D) 300 N in a direction 26.6° north of west
E) 2100 N in a direction 26.6° north of west

1.4 Which of the graphs in the figure below illustrates Hooke's Law?

A) Graph a
B) Graph b
C) Graph c
D) Graph d



1.5 A small glider is coasting horizontally when suddenly a very heavy piece of cargo falls out of the bottom of the plane. You can neglect air resistance. Just after the cargo has fallen out:

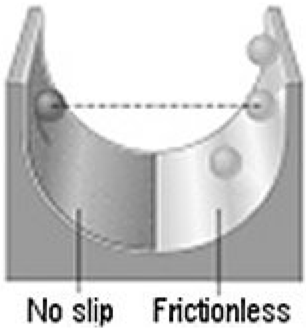
A) the plane speeds up and the cargo slows down.
B) the plane speeds up but the cargo does not change speed.
C) neither the cargo nor the plane change speed.
D) the cargo slows down but the plane does not change speed.
E) both the cargo and the plane speed up.

1.6 A turbine blade rotates with angular velocity $\omega(t) = 2.00$ rad/s - 2.1.00 rad/s^3 t^2. What is the angular acceleration of the blade at $t = 9.10$ s?

A) -38.2 $\mathrm{rad.s^{-2}}$
B) -19.1 $\mathrm{rad.s^{-2}}$
C) -86.0 $\mathrm{rad.s^{-2}}$
D) -36.2 $\mathrm{rad.s^{-2}}$
E) -172 $\mathrm{rad.s^{-2}}$

1.7 A ball is released from rest on a no-slip surface, as shown in the figure. After reaching its lowest point, the ball begins to rise again, this time on a frictionless surface as shown in the figure. When the ball reaches its maximum height on the frictionless surface, it is:

A) at a greater height than when it was released.
B) at a lesser height than when it was released.
C) at the same height than when it was released.
D) It is impossible to tell without knowing the mass of the ball.
E) It is impossible to tell without knowing the radius of the ball.



1.8 A heavy boy and a lightweight girl are balanced on a massless seesaw. If they both move forward so that they are one-half their original distance from the pivot point, what will happen to the seesaw? Assume that both people are small enough compared to the length of the seesaw to be thought of as point masses.

A) It is impossible to say without knowing the masses.
B) It is impossible to say without knowing the distances.
C) The side the boy is sitting on will tilt downward.
D) Nothing will happen; the seesaw will still be balanced.
E) The side the girl is sitting on will tilt downward.

1.9 A baseball is located at the surface of the earth. Which statements about it are correct? (There may be more than one correct choice.)

A) The earth exerts a much greater gravitational force on the ball than the ball exerts on the earth.
B) The ball exerts a greater gravitational force on the earth than the earth exerts on the ball.
C) The gravitational force on the ball due to the earth is exactly the same as the gravitational force on the earth due to the ball.
D) The gravitational force on the ball is independent of the mass of the ball.
E) The gravitational force on the ball is independent of the mass of the earth.

1.10 A restoring force of magnitude F acts on a system with a displacement of magnitude x. In which of the following cases will the system undergo simple harmonic motion?

A) $F \propto \sqrt{x}$
B) $F \propto \sin x$
C) $F \propto x^2$
D) $F \propto x$
E) $F \propto 1/x$

<u>Question 2 Follows on next page</u>

<u>Question 2</u> [10]

2.1 A student throws his first year Physics textbook into the air with an initial velocity v_0. Another student drops his first year Physics textbook at the same instants. Ignore air resistance. Make use of a discussion to compare the accelerations of the two textbooks. (2)

2.2 Two projectiles are thrown with the same initial speed, one at an angle θ with respect to level ground and the other at an angle $(90^{\mathrm{o}} - \theta)$. Both the projectiles strike the ground at the same distance from the launch point. Were both the projectiles in the air for the same length of time? Make use of the appropriate arguments to discuss your answer. (2)

2.3 A bucket of water can be rotated in a vertical path such that no water is spilled. Why does the water remain in the bucket, even when the pail is upside down above your head? Make use of the appropriate Physics arguments to explain your answer. (2)

2.4 Consider the following:

A 3kg weight is connected to a spring with a spring constant of 10 $N.m^{-1}$. The spring-mass system is suspended vertically from the ceiling such that the mass hang from the spring. The system is allowed to get to its equilibrium point. If the mass is displaced downward by 2 cm from its equilibrium point and released, the mass will oscillate up and down. Assume that air resistance is neglected, discuss using the appropriate physics if the total mechanical energy of the system is conserved. (2)

2.5 If the amplitude of a system moving in simple harmonic motion is doubled, which of the following quantities does not change and explain using the appropriate Physics why you made a particular choice. The quantities are: a) total energy, b) maximum speed, c) maximum acceleration and d) period. (2)

<u>Question 3</u> [20]

3.1 Sally is driving along a straight highway in her 1965 Mustang. At t = 0, when she is moving in positive x-direction, she passes a signpost at x = 50 m. Her acceleration is function of time is given by:

$$a_x = 2\ \mathrm{m.s^{-2}} - (0.1\ \mathrm{m.s^{-3}})t.$$

Given: $\int t^n\,\mathrm{d}t = {}^{1}/_{(n+1)}\, t^{n+1} + c$

a) Make use of her acceleration as function of time to obtain her velocity as function of time. (2)

b) Obtain her position as function of time. (2)

c) When is her x – velocity the greatest? (2)

d) Calculate her maximum velocity. (2)

3.2 A web page designer creates an animation in which a dot on a computer screen has a position:

$$\bar{\boldsymbol{r}} = [4.4\text{ cm} + (2.8\text{ cm.s}^{-2})t^2]\hat{\boldsymbol{\imath}} + (5.5\text{ cm.s}^{-1})t\hat{\boldsymbol{\jmath}}.$$

a) Calculate the dot's average velocity between $t = 0$ and $t = 2$ s. (6)

b) Calculate the dot’s instantaneous velocity between the two points in a). (4)

c) Sketch the dot’s trajectory from t = 0 and t = 2 s (2)

Question 4 follows on next page

<u>Question 4</u> [8]

Your firm needs to move granite blocks up a 15^{o} slope out of a quarry and then, to lower dirt into the quarry to fill the holes. You design a system in which a granite block on a cart with steel wheels (cart and block is w_1) is pulled uphill on steel rails by dirt-filled bucket (dirt and bucket is w_2) that descents vertically into a shaft next to the quarry. Make use of Newton's laws in order to calculate the relationship between w_1 and w_2 so that the system can move at a constant velocity. Ignore the weight of the cable and friction of pulley and wheels. (8)

<u>Question 5</u> [14]

5.1 Consider a non-deformable object of mass m moving in the positive x – direction under a force **F** that is not constant. The mass had an initial position $\boldsymbol{x}_i$, with an initial velocity $\boldsymbol{v}_i$. After the force was applied the position of the object is $\boldsymbol{x}_f$ with a final velocity $\boldsymbol{v}_f$. Make use of the principle of work done by the force in order to show that the work – energy theorem is given by:

$$W = \Delta K,$$

where K is the kinetic energy of the object. (6)

5.2 Two blocks with different masses are attached to either end of a light rope that passes over a light, frictionless pulley. The pulley is suspended from the ceiling. The masses are released from rest, and the more massive starts to descend. After the massive block descended 1.2 m, its speed is 3 $m.s^{-1}$. If the sum of the two masses is 22 kg, make use of the conservation of mechanical energy in order to calculate the mass of each block. (8)

<u>Question 6</u> [14]

6.1 Consider two masses m_1 and m_2 with respective initial velocities $\boldsymbol{v}_{1i}$ and $\boldsymbol{v}_{2i}$. These two masses interact in a collision and are then left with final velocities $\boldsymbol{v}_{1f}$ and $\boldsymbol{v}_{2f}$. Make use of this information and the necessary physics and equations in order to show that the momentum of a closed system is conserved or:

$$\boldsymbol{p}_{1i} + \boldsymbol{p}_{2i} = \boldsymbol{p}_{1f} + \boldsymbol{p}_{2f}.$$ (4)

6.2 A 2500 kg car traveling east with a speed of 25 $m.s^{-1}$ collides at an intersection with a second car of mass 1500 kg, travelling north at a velocity of 20 $m.s^{-1}$. Assume that the cars stick together after the collision.

Calculate the velocity and direction of the cars after the collision. (10)

<u>Question 7</u> [16]

7.1 Derive the equation below for an object of which its angular speed changes with $\Delta\omega$ in time Δt.

$$a_t = r\alpha \, .$$

Make the meaning of all symbols clear in your answer. (3)

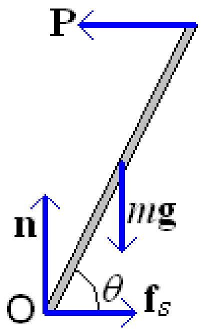
<u>Given:</u> $v_t = r\omega$

7.2 A play-ground merry-go-round has a radius r = 2.2 m and a moment of inertia of I = 2400 kg.m^2 about a vertical axis through its center. A child applies a tangential force of 21 N at its edge of the merry-go-round that is initially at rest, for 17 s. Assume the merry-go-round turns without any friction.

a) Calculate the angular acceleration of the merry-go-round. (3)

b) Make use of the equation of motion in order to calculate its angular velocity. (2)

7.3 A uniform ladder, the figure below, of length ℓ and mass m rests against a smooth vertical wall. The coefficient of static friction between the ladder and the ground is μ_s = 0.4. Calculate the minimum angle θ_{min} at which the ladder does not slip. (8)



<u>Question 8</u> [15]

8.1 Consider a spring with a spring constant *k* that is attached to one end to a mass *m*, while the other end is attached to a solid structure. The mass rests on a frictionless horizontal surface. An external force **F** moves the mass a distance ***x*** from the equilibrium position. If the force is removed the spring-mass will oscillate. Show that for this spring mass system the acceleration of the mass is directly proportional to the negative of the distance:

$$a = -\frac{k}{m}x. \qquad (3)$$

8.2 A 200 g block connected to a spring with k = 5 N.m^{-1} is free to oscillate on a horizontal, frictionless surface. The block is displaced 5 cm from equilibrium and released at $t = 0$.

a) Calculate the period of the block. (2)

b) Calculate the maximum speed of the block. (2)

c) Determine the maximum acceleration of the block. (2)

d) Express the position, velocity and acceleration as function of time. (6)

<u>Question 9</u> [8]

9.1 Consider two identical waves moving in opposite directions. The two wave are:

$$y_1 = A\sin(kx - \omega t) \text{ and } y_2 = A\sin(kx + \omega t).$$

a) Make use of the superposition of the two waves to show that:

$$y = 2A\sin(kx)\cos(\omega t)\ .$$

(4)

<u>Given:</u> $\sin(a \pm b) = \sin a \cos b \pm \cos a \sin b$

b) Discuss in your own words what is meant by a node and then show that a node will happen at:

$$x = \frac{n\lambda}{2}\ n = 1, 2, 3.$$

(4)

END OF PAPER