UNIVERSITY EXAMINATIONS

UNIVERSITEITSEKSAMENS

UNISA university of south africa

PHY1505

October/November 2014

MECHANICS (PHYSICS)

Duration 2 Hours

100 Marks

EXAMINERS
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Use of a non-programmable pocket calculator is permissible.

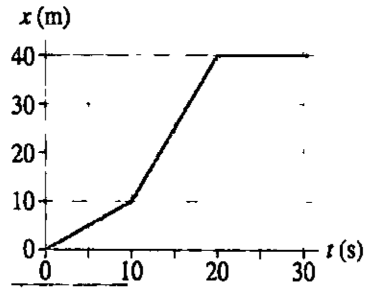
Closed book examination.

This examination question paper remains the property of the University of South Africa and may not be removed from the examination venue.

- This paper consists of 5 pages plus instructions for the completion of a mark reading sheet.
- Mark allocation for each question is indicated in brackets to the right
- Physical constants and mathematical formulae are given at the end of the paper
- ANSWER ALL THE QUESTIONS

[TURN OVER]

1 (a) The motion of an object along a straight line is described by the graph shown below.



Describe the motion in words. (8)

(b) A 1.0 kg rocket with a thrust of 2.0 N is released from rest on top of a 2.0 m high frictionless table. The rocket travels 4.0 m on the table before dropping off the edge of the table. How far does the rocket land from the base of the table? (12)

[20]

2 (a) Define force in terms of momentum. (4)

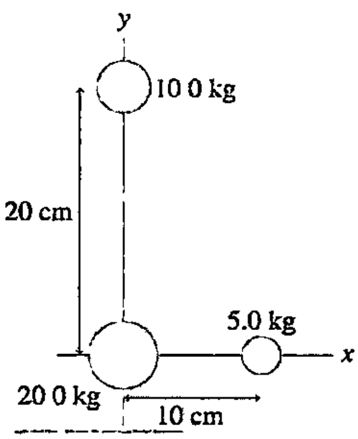
(b) A man whose mass is 75 kg starts to slide down a 50 m high frictionless slope of angle 20°. A strong headwind exerts a horizontal force of 200 N on him as he slides. Calculate his speed at the bottom of the slope

i using work and energy. (8)

ii using Newton's laws. (8)

[20]

3 (a) The figure below shows three masses.



Calculate the magnitude and the direction of the net gravitational force on

i the 20.0 kg mass (8)

ii the 5.0 kg mass. Give the direction as an angle. (7)

[TURN OVER]

(b) The speed of a satellite in a circular orbit of radius r around a planet of mass M is $v = \sqrt{\frac{GM}{r}}$. Determine the equation relating the period T of the satellite and the radius r (5)

[20]

4. (a) Calculate the moment of inertia of a thin rod of length L and mass M with uniform density, rotating about an axis through one end of the rod (10)

(b) A 15 cm long 200 g rod is pivoted at one end A 20 g ball of clay is stuck on the other end What is the period if the rod and clay ball swing as a pendulum? (10)

[20]

5 (a) Write down Bernoulli equation for fluids and explain what all the symbols in the equation represent (6)

(b) A 2 0 mL syringe has an inner diameter of 6.0 mm, a needle with inner diameter 0.25 mm, and a plunger pad (where you place your finger) diameter of 1 2 cm. A nurse uses the syringe to inject medicine into a patient whose blood pressure is 140/100

i. What is the minimum force the nurse needs to apply to the syringe? (7)

ii The nurse empties the syringe in 2 0 s What is the flow speed of the medicine through the needle? (7)

[20]

PHYSICAL CONSTANTS AND MATHEMATICAL FORMULAE

Physical Constants

gravitational constant	$G = 6\ 67 \times 10^{-11}\,\mathrm{N\,m^2\,kg^{-2}}$
gravitational acceleration	$g = 9\ 81\, m\, s^2$
mass of the Sun	$M_S = 1.99 \times 10^{30}\,\mathrm{kg}$
radius of the Sun	$R_S = 6\ 96 \times 10^8\,\mathrm{m}$
mass of the Earth	$M_E = 6\ 0 \times 10^{24}\,\mathrm{kg}$
radius of the Earth	$R_E = 6\ 4 \times 10^6\,\mathrm{m}$
760 mm of Hg	$1\,\mathrm{atm} = 1\ 013 \times 10^5\,\mathrm{Pa}$

Differentiation

$\frac{d}{dx}x^n = nx^{n-1}$

$\frac{d}{dx}e^{ax} = a\,e^{ax}$

$\frac{d}{dx}\ln x = \frac{1}{x}$

$\frac{d}{dx}\sin x = \cos x$

$\frac{d}{dx}\cos x = -\sin x$

$\frac{d}{dx}\sinh x = \cosh x$

$\frac{d}{dx}\cosh x = \sinh x$

$\frac{d}{dx}\mathrm{cosec}x = -\mathrm{cosec}x\,\cot x$

$\frac{d}{dx}\sec x = \sec x\,\tan x$

$\frac{d}{dx}\tan x = \sec^2 x$

$\frac{d}{dx}\sin^{-1}\left(\frac{x}{a}\right) = \frac{1}{\sqrt{a^2-x^2}}$

$\frac{d}{dx}\cos^{-1}\left(\frac{x}{a}\right) = \frac{-1}{\sqrt{a^2-x^2}}$

$\frac{d}{dx}\tan^{-1}\left(\frac{x}{a}\right) = \frac{a}{a^2+x^2}$

$\frac{d}{dx}\sinh^{-1}\left(\frac{x}{a}\right) = \frac{1}{\sqrt{x^2+a^2}}$

$\frac{d}{dx}\cosh^{-1}\left(\frac{x}{a}\right) = \frac{-1}{\sqrt{x^2-a^2}}$

$\frac{d}{dx}\tanh^{-1}\left(\frac{x}{a}\right) = \frac{a}{a^2-x^2}$

$\frac{d}{dx}(u\,v) = \frac{du}{dx}v + u\frac{dv}{dx}$

$\frac{d}{dx}\left(\frac{u}{v}\right) = \frac{1}{v^2}\left[\frac{du}{dx}v - u\frac{dv}{dx}\right]$

Definite Integrals

$$\int_0^{\infty} x^n\,e^{-ax}\,dx = \frac{n!}{a^{n+1}} \qquad (n \geq 0 \quad \text{and} \quad a > 0)$$

$$\int_{-\infty}^{+\infty} e^{-ax^2}\,dx = \sqrt{\frac{\pi}{a}}$$

$$\int_{-\infty}^{+\infty} x^2\,e^{-ax^2}\,dx = \frac{1}{2}\sqrt{\frac{\pi}{a^3}}$$

$$\int_a^b u\,\frac{dv}{dx}\,dx = uv\Big|_a^b - \int_a^b \frac{du}{dx}\,v\,dx$$

$$\text{moment of inertia} \quad I_{a+b} = I_a + I_b$$

Trigonometry

$\sin(a \pm b) = \sin a\,\cos b \pm \cos a\,\sin b$

$\cos(a \pm b) = \cos a\,\cos b \mp \sin a\,\sin b$

$\tan(a \pm b) = \dfrac{\tan a \pm \tan b}{1 \mp \tan a\,\tan b}$

$\sin 2a = 2\,\sin a\,\cos a$

$\cos 2b = \cos^2 b - \sin^2 b$

$\sin a + \sin b = 2\,\sin\frac{1}{2}(a+b)\,\cos\frac{1}{2}(a-b)$

$\sin a - \sin b = 2\,\sin\frac{1}{2}(a-b)\,\cos\frac{1}{2}(a+b)$

$\cos a + \cos b = 2\,\cos\frac{1}{2}(a+b)\,\cos\frac{1}{2}(a-b)$

$\cos a - \cos b = -2\,\sin\frac{1}{2}(a+b)\,\sin\frac{1}{2}(a-b)$

$e^{\pm i\theta} = \cos\theta \pm i\,\sin\theta$

$\cos\theta = \frac{1}{2}[e^{i\theta} + e^{-i\theta}]$

$\sin\theta = \frac{1}{2i}[e^{i\theta} - e^{-i\theta}]$

$e^{\pm x} = \cosh x \pm \sinh x$

$\cosh\theta = \frac{1}{2}[e^{\theta} + e^{-\theta}]$

$\sinh\theta = \frac{1}{2}[e^{\theta} - e^{-\theta}]$

$\cosh^2 x - \sinh^2 x = 1$

$\sin^2\theta = \frac{1}{2}\left[1 - \cos(2\theta)\right]$

$\cos^2\theta = \frac{1}{2}\left[1 + \cos(2\theta)\right]$

Vectors

$$\vec{A}\cdot\vec{B} = A_xB_x + A_yB_y + A_zB_z = |\vec{A}||\vec{A}|\cos\theta$$

$$\vec{A}\times\vec{B} = \left(A_yB_z - A_zB_y\right)\hat{\imath} + \left(A_zB_x - A_xB_z\right)\hat{\jmath} + \left(A_xB_y - A_yB_x\right)\hat{k}$$

$$\vec{A}\;\;(\vec{B}\times\vec{C}) = \vec{B}\;\;(\vec{C}\times\vec{A}) = \vec{C}\cdot(\vec{A}\times\vec{B})$$

$$\vec{A}\times(\vec{B}\times\vec{C}) = (\vec{A}\cdot\vec{C})\vec{B} - (\vec{A}\cdot\vec{B})\vec{C}$$

$$\vec{\nabla}\phi = \frac{\partial\phi}{\partial x}\hat{\imath} + \frac{\partial\phi}{\partial y}\hat{\jmath} + \frac{\partial\phi}{\partial z}\hat{k}$$

$$\vec{\nabla}\;\;\vec{A} = \frac{\partial A_x}{\partial x} + \frac{\partial A_y}{\partial y} + \frac{\partial A_z}{\partial z}$$

$$\vec{\nabla}\times\vec{A} = \left(\frac{\partial A_z}{\partial y} - \frac{\partial A_y}{\partial z}\right)\hat{\imath} + \left(\frac{\partial A_x}{\partial z} - \frac{\partial A_z}{\partial x}\right)\hat{\jmath} + \left(\frac{\partial A_y}{\partial x} - \frac{\partial A_x}{\partial y}\right)\hat{k}$$

$$\vec{\nabla}\;\;\vec{\nabla}\phi = \frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} + \frac{\partial^2\phi}{\partial z^2}$$

$$\vec{\nabla}\times(\vec{\nabla}\phi) = 0 \qquad \text{and} \qquad \vec{\nabla}\;\;(\vec{\nabla}\times\vec{A}) = 0$$

$$\vec{\nabla}\times(\vec{\nabla}\times\vec{A}) = \vec{\nabla}(\vec{\nabla}\cdot\vec{A}) - \nabla^2\vec{A}$$