UNIVERSITY OF BOTSWANA

2004/05 SEMESTER 1 FINAL EXAMINATION

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COURSE CODE: PHY111 **CREDITS: 3** **DURATION: 2 Hrs.**

TITLE OF PAPER: GEOMETRICAL OPTICS, MECHANICS AND VIBRATIONS AND WAVES

TITLE OF EXAMINATION: B.Sc./B.Ed.1

SUBJECT: PHYSICS **DATE: NOV./DEC. 2004**

INSTRUCTIONS:

SECTION A: Answer ALL (FIVE) short questions of **Section A** within the space provided in the worksheets.

At the end of the examination, hand in the worksheets (pages 5 to 8) along with your answer script. Each question carries 5 marks.

SECTION B: Answer **any THREE (3)** questions from **Section B.**

Each question carries 25 marks.

Where necessary use the following:

Radius of the earth, $R_e = 6.37 \times 10^6$ m

Magnitude of acceleration due to gravity, $g = 9.8 m\ s^{-2}$

Refractive index of air, $n_a = 1.00$

Velocity of light in vacuum, $c = 3.0 \times 10^8\ m\ s^{-1}$

DO NOT OPEN THIS PAPER UNTIL YOU HAVE BEEN TOLD TO DO SO BY THE SUPERVISOR.

No. of Pages including this cover: **8 (EIGHT)**

SECTION B

(Answer any **THREE (3)** questions out of four from Section B)

B1. **(a)** Draw a ray diagram to show image formation from a convex mirror and use the diagram to derive the mirror equation. **(10 marks)**

(b) Draw a well-labelled ray diagram to illustrate the principle of the simple microscope. **(5 marks)**

(c) Two lenses, one concave and the other convex, have equal magnitudes of focal lengths of 30 cm and are placed 100 cm apart. A candle is placed 40 cm away from the convex lens on the side opposite that on which the concave lens is placed. Calculate the position of the final image formed by this combination of lenses and characterize it. **(10 marks)**

B2. At time t = 0, a projectile is fired from the top of a building that is 270 m above ground with an initial velocity of 30 ms^{-1} and at an angle of 30° above the horizontal. At the same time (i.e t = 0), a ball is thrown vertically up from the ground with initial velocity **u** ms^{-1} at a horizontal distance of 200 m from the building. If the ball and the projectile collide, find:

(a) the time it would take before the ball and the projectile collide **(5 marks)**
(b) the height above ground when the ball and the projectile collide **(6 marks)**
(c) the initial velocity of the ball **(5 marks)**
(d) the maximum height reached by the ball **(4 marks)**
(e) time taken by the ball to reach its maximum height **(4 marks)**
(f) deduce the direction in which the ball was going when it collided with the projectile. **(1 mark)**

B3. **(a)** A box of mass m_1 = 10.0 *kg* rests on a rough surface inclined at θ = 37° to the horizontal. It is connected by a light, inextensible cord that pass over a massless and frictionless pulley, to a second box of mass m_2 hanging freely as shown in the figure below. If m_2 is small enough, m_1 would slide-down the incline and if it is large enough, m_1 would slide-up the incline.

(a) Draw free-body diagrams for boxes m_1 and m_2 for the case of m_1 sliding down the incline. **(4 marks)**

(b) Draw free-body diagrams for boxes m_1 and m_2 for the case of m_1 sliding up the incline **(4 marks)**

(c) Use the free-body diagrams in (b) and Newtons laws to determine the expression for acceleration of the blocks up the incline. **(7 marks)**

(d) If the coefficient of static friction, $\mu_s = 0.40$, determine the maximum value that m_2 can have without causing motion of m_1 up the incline. **(5 marks)**

(e) Calculate the work done against friction when m_1 moves a distance of 2 m up the incline and the coefficient of kinetic friction, $\mu_k = 0.30$. **(5 marks)**

B4. **(a)** Two particles, X and Y, of masses m_1 and m_2 undergo simple harmonic oscillations of amplitudes A_1 and A_2, periods T_1 and T_2 and force constants k_1 and k_2, respectively. If the total energy of X is four times the total energy of Y, show that

$$\frac{T_1}{T_2} \quad \frac{2A_1}{A_2}\sqrt{\frac{m_1}{m_2}}$$ **(15 marks)**

(b) The displacement of a lightly damped harmonic motion of a mass m suspended from a spring of force constant k is given by:

$$y(t) = y_o e^{-\frac{\Gamma}{2}t}\cos(\omega t)$$

where Γ is the damping constant, and the frequency T is given as:

$$\omega = \sqrt{\frac{k}{m} - \frac{\Gamma^2}{4}}$$

The amplitude of oscillations after 5 cycles falls to (1/e) of the amplitude at t = 0. If m = 0.1 kg, and k = 50 N m^{-1}, Calculate the value of the damping constant Γ. **(10 marks)**

MAKE SURE YOU:

Fill-in all your details on the answer script and on the Section-A cover sheet.

Submit Section-A work sheets along with your answer script (i.e. pages 5 to 8).

-=::End of PHY111 Examination Nov./Dec 2004::=-

UNIVERSITY OF BOTSWANA

Department of Physics

PHY111: **Semester 1 Final Examination** **Nov./Dec. 2004**

SHORT QUESTIONS WORKSHEETS (SECTION A)

Name:_____
(Last/Family name) **(First/Other names)**

ID No.:_____ **Tutorial Group:**_____

<u>DO NOT</u> write in the space below.
For Examiners' Use Only.

Question No.	Marks	Section Marks
SECTION A		
SECTION (B)		
B1		
B2		
B3		
B4		
TOTAL (100)		

SECTION A

Answer <u>ALL (5)</u> Questions of this section in the space provided below each question.

A 45^0-45^0-90^0 prism is made from a material of refractive index 1.52.

(a) Calculate the critical angle if the prism is surrounded by air.

(b) Draw a suitable diagram to show how this prism can be used to bend a ray of light through 90°

Two vectors are given by $\overline{A} = 6\hat{i} + 5\hat{j} - 7\hat{k}$ and $\overline{B} = -4\hat{i} - 9\hat{j} + 3\hat{k}$. Evaluate $\overline{A} - \overline{B}$ and $\overline{A} \bullet \overline{B}$

A3. Determine the centripetal force acting on a cosmonaut-engineer of mass 79 kg moving in a circular orbit around the Earth with a constant speed of 7.6 km s^{-1} at an altitude of 520 km above the surface of the Earth.

A4. A mass of 20g suspended from a spring gives a period of 2 s when set into simple harmonic motion. The 20 g mass is removed and a mass M is suspended from the same spring and set into simple harmonic motion giving a period of 3 s. Determine the value of M.

A5. The displacement in metres due to a plane transverse wave travelling through a medium is given by:

$$y(x,t) = 0.05 \sin \{2\pi(0.01x - 2t)\}$$

Determine the amplitude, angular frequency, wavelength and velocity of the waves in the medium.