THE COPPERBELT UNIVERSITY

SCHOOL OF MATHEMATICS AND NATURAL SCIENCES

DEPARTMENT OF PHYSICS

PH 110 TEST 1, 30 MARCH 2023

INSTRUCTIONS: ***DURATION: 2.0 HRS 30 MINUTE*** ($2\frac{1}{2}$ *hrs*)

ANSWER ALL questions. *Each question carries 25 marks. You may tackle the questions in any order provided they are correctly and clearly numbered. Essential working must be shown to avoid loss of marks. Clearly write your* **full names, computer number** *and* **lecture group**.

Whenever necessary, use the following constants: $g = 9.8\ \text{m/s}^2$,
2.54 cm = 1 inch, 1 ft = 30.48 cm, 1 mile=1609 m =1.609 km, 1 ton = 1000 kg

QUESTION ONE.

(a) When taking measurements in an experiment, the results are expected to be both accurate and precise. Distinguish between **accuracy** and **precision**. **[3]**

(b) If the length and width of a rectangular plate are measured to be (17.30 ± 0.05) cm and (13.30 ± 0.05) cm, respectively, find the area of the plate and the approximate uncertainty in the calculated area. **[4]**

(c) A solid cube is 350 g and each edge has length of 5.35 cm. Determine the density ρ of the cube in SI units. **[4]**

(d) The speed v of an object is given by the equation $v = At^3 - Bt$, where t refers to time. What are the dimensions of A and B? **[4]**

(e) (i) Write down the dimensions of **velocity, force and density** **[4]**

(ii) A Toyota Harrier moving with velocity v experiences a force F due to air resistance given by the express;

$$F = \tfrac{1}{5} C\rho^x v^y A^z$$

where C is a dimensionless constant called the drag coefficient, ρ is the density of the air and A is the cross section area of the vehicle. Use dimensional analysis to find the values of the powers of x, y and z. **[6]**

QUESTION TWO

(a) State **three** methods used to graphically add vectors. **[3]**

(b) Define the terms listed below and give **two** examples in each case:
i) Scalar quantities, and ii) Vector quantities. **[4]**

(c) You find yourself, in a deep thought about a physics problem. First you walk 3.5 meters due south. Then, you walk 8.2 meters due northeast. Then you doze off and find yourself 15.0 meters due west. Determine how far you walked while you were lost in the deep thought. **[5]**

(d) Define a unit vector **[2]**

(e) Let a force $\boldsymbol{F} = (5\hat{\imath} + A_y\hat{\jmath} + 4\hat{k})$N act on an object over a displacement $\boldsymbol{R} = (3\hat{\imath} - \hat{\jmath} + 2\hat{k})$ m. Given that the force $\boldsymbol{F}$ has a magnitude of $\sqrt{90}$. Determine or otherwise as indicated,

(i) the value of A_y **[2]**

(ii) the unit vector of $\boldsymbol{F}$ **[2]**

(iii) the **dot** product of $\boldsymbol{F}$ and $\boldsymbol{R}$. **[3]**

(iv) a vector perpendicular to $\boldsymbol{F}$ and $\boldsymbol{R}$ **[2]**

(f) Find the magnitude of the **cross product** for a force given by $\mathbf{F} = (2\hat{\imath} + \hat{\jmath} + 2\hat{k})N$ acting at 30° angel to the radius $\boldsymbol{R} = (\hat{\imath} + \hat{\jmath} + \hat{k})\,m$. **[2]**

QUESTION THREE

(a) Define (i) Uniform motion (ii) Acceleration. **[2, 2]**

(b) A stone is dropped from a balloon that is 72.5 m above the ground and rising vertically. The stone reaches the ground in 5 s. What was the velocity of the balloon just at an instant the stone was dropped? **[3]**

(c) Police officers in a parked patrol car hidden at the intersection, observes a bus that ignores a stop sign, crosses the intersection, and continue moving at constant velocity. 2 seconds after the bus has crossed the intersection, the patrol car starts off in pursuit in the same direction as the bus, accelerating uniformly until it catches the bus with velocity of 48 m/s. At that instant, the bus is 240 m from the intersection. How fast was the bus travelling? **[6]**

(d) At a funfair, a prize is awarded when a coin is tossed into a small dish. The dish is mounted on a shelf above the ground as shown in **Fig.3.1**.

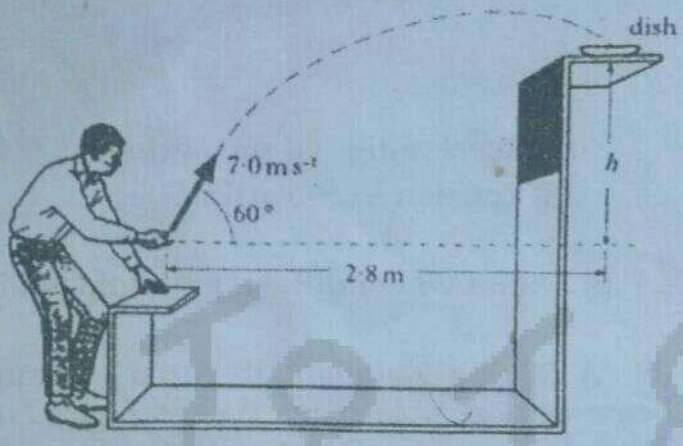


Fig.3.1

A contestant projects the coin with a speed of 7 ms^{-1} at an angle of 60° to the horizontal. When the coin leaves his hand, the horizontal distance between the coin and the dish is 2.8 m. The coin lands in the dish. The effect of air friction may be neglected.

(i) Calculate the horizontal and vertical components of initial velocity of the coin. **[2]**

(ii) Show that the time taken for the coin to reach the dish is 0.8 s. **[2]**

(iii) What is the height, *h*, of the shelf above the point where the coin leaves the contestant's hands? **[3]**

(iv) What is the velocity of the coin when it enters the dish compare with the velocity of the coin just as it leaves the contestant's hands? **[5]**

QUESTION FOUR

In **Fig. 4.1**, a 1 kg mass on a rough horizontal surface is joined to a 2 kg mass by a light, inextensible string running over a frictionless pulley. The coefficient of kinetic friction between the 1 kg mass and the surface is 0.13.

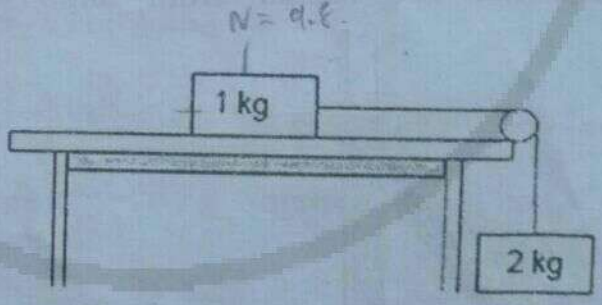


Fig.4.1

(a) State Newton's second law of motion in words **[2]**

(b) Calculate the magnitude of the:

(i) Kinetic frictional force acting on the 1 kg mass. **[3]**

(ii) Acceleration of the system. [6]

(iii) Tension in the string. [2]

(c) (i) State **two** conditions for static equilibrium. [2]

(ii) A 20.0kg floodlight in a park is supported at the end of a horizontal beam of negligible mass that is hinged to a pole as shown in Figure 4.2. A cable at an angle of 30.0° with the beam helps to support the light. Sketch a free-body diagram of the system and determine the tension in the cable. [4]

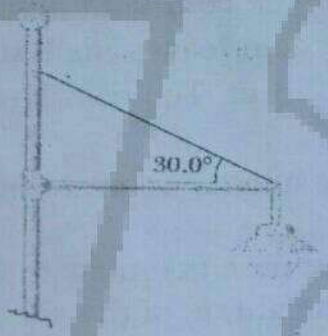


Fig 4.2

(e) A uniform ladder of length 6.0 m and weight 300N rests against a slipping vertical wall as shown in **Fig4.3**. The inclination angle between the ladder and the rough floor is 37°.Using your sketched free-body diagram; determine the **reaction forces from the floor** and **from the wall on the ladder** and the **static friction coefficient** at the interface of the ladder with the floor that prevents the ladder from slipping. [6]

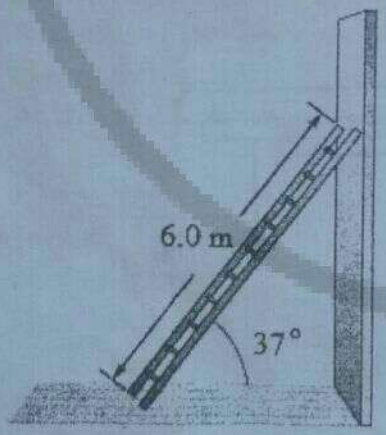


Fig 4.3

THE COPPERBELT UNIVERSITY
SCHOOL OF MATHEMATICS AND NATURAL SCIENCES
DEPARTMENT OF PHYSICS

PH 110: Introductory Physics

TEST 2 **DATE: 10th July 2023** **TIME: 2 hours**

INSTRUCTIONS:
Attempt **ANY THREE QUESTIONS, TOTAL MARKS 75.** Marks for each question or part of it are given in square brackets **[ ]**. Write your **Names, computer number** and **lecture Group** clearly on your answer scripts. Essential working must be shown to avoid loss of marks. Where necessary use the following constants or expressions:

$g = 9.8\,\text{m/s}^2$, $G = 6.673\times10^{-11}\,\text{N.m}^2\text{.kg}^{-2}$, Mass of the Earth $M_E = 5.98\times10^{24}\,\text{kg}$, Radius of the Earth $R_E = 6.37\times10^{6}\,\text{m}$, $M_S = 1.99\times10^{30}\,\text{kg}$.

$$I_{disc} = \frac{1}{2}MR^2,\ I_{Sphere} = \frac{2}{5}MR^2,\ L = I\omega,\ I = \int r^2 dm,\ W = \int F_x dx$$

QUESTION ONE

(a) (i) A fisherman returning from a successful fishing trip pulls a cooler box loaded with fish. The total mass of the box and fish is 50.0 kg, and the fisherman exerts a force of 1.2×10^2 N on the box by pulling on the rope, how much work does he do on the box if the rope is pulled at an angle of 30.0° to the horizontal for a distance of 5.0 m? **[2]**

(ii) Suppose that in (a) (i) above, the coefficient of kinetic friction between the loaded 50.0-kg box and surface is 0.2. The fisherman again pulls the box 5.0 m, exerting the same force of 1.2×10^2 N, but this time at an angle of 0°. Find the work done on the box by **friction**, and the **net work done.** **[5]**

(b) A 2.0 kg box slides down an incline against a frictional force of 3.0 N acting in the opposite direction to its motion as shown in Figure 1.1.

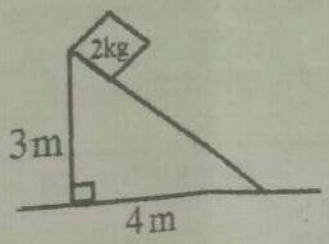


Figure 1.1

As the box slides down, determine the amount of work done by:

(i) the normal force [2]
(ii) gravity [2]
(iii) friction [2]
(iv) the net work done on the box [2]

(c) John is driving home from work. His roller coaster car of mass 400 kg runs out of petrol just as he reaches the top of a hill that is 50 m (**point A**). He is driving at constant speed of 25 m/s when he reaches the top of the hill. His car then moves down the hill without friction and comes to rest at the next hill of height h (**point B**) as shown in Figure 1.2.

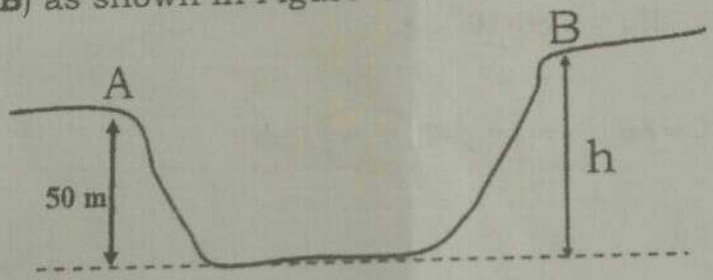


Figure 1.2

(i) Calculate the total mechanical energy at the top of the first hill. [3]

(ii) If mechanical energy is conserved, calculate the height h at which the car comes to rest on the second hill. [3]

(d) A 1.00×10^3 kg elevator carries a maximum load of 8.00×10^2 kg. A constant frictional force of 4.00×10^3 N retards its motion upward. What minimum power, in kilowatts must the motor deliver to lift the fully loaded elevator at a constant speed of 3.00 m/s? [5]

QUESTION TWO

a) i) State the law of conservation of momentum [2]
ii) Define the term Impulse [2]
iii) What is meant by the term inelastic collision [2]
b) Show that the impulse of a body is equal to the change in its momentum. [4]
c) In a crash test, a car of mass 2000 Kg traveling westward collides with a wall and rebounds east. The initial and final velocities of the car are $v_i = -20$ m/s and $v_f = 5.4$ m/s, respectively. Find the impulse delivered to the car due to the collision [2]

d) An object of mass $m_1 = 20.00\,kg$ traveling at an angle of 150^0 with respect to the positive x-axis with an initial velocity of 25.00 m/s, collides with an object of mass $m_2 = 30.00\,kg$ traveling with a velocity of 20.00 m/s at an angle of 20^0 with respect to the positive x-axis. Assume a perfect elastic collision.

i) Find the x and y components of initial velocity of m_1 [2]
ii) Find the x and y components of initial velocity of m_2 [2]
iii) Find the x and y components of final velocity of m_1 [5]
iv) Find the x and y components of final velocity of m_2 [4]

QUESTION THREE

(a) In aviation, a "standard turn" for a level flight of a propeller-type plane is one in which the plane makes a complete circular turn in 2.00 minutes. If the speed of the plane is 250 m/s,
(i) What is the radius of the circle? [2]
(ii) What is the centripetal acceleration of the plane? [2]

(b) A 35 kg boy is swinging on a rope 6.4 m long. He passes through the lowest position with a speed of 3.5 m/s. What is the tension on the rope at that moment? [3]

(c) An engineered sports car whose speed is increasing at a rate of 0.6 m/s^2 travels along a circular road of radius $r = 15m$. When the instantaneous speed of the vehicle is 5 m/s, find
(i) The tangential acceleration component. [2]
(ii) The centripetal acceleration component. [2]
(iii) The magnitude of the total acceleration. [2]

(d) (i) State the law of universal gravitation. [2]
(ii) Show that the period T for a satellite orbiting the Earth is equal

$$T = \sqrt{\frac{4\pi^2 r^3}{GM_E}}$$ where M_E is the mass of the Earth, r is the orbital radius and G has its usual meaning (gravitational constant) [4]

(e) Communication satellites are placed in "geosynchronous" orbits around the Earth. This means the satellite must have the same orbital period as the Earth (24 hours).

(i) At what height **above** the surface of the Earth must one place such a satellite to archive geosynchronous? [4]
(ii) What's the orbital speed of the satellite? [2]

QUESTION FOUR

a) A CBU SoM student in a medical imaging system is studying the rotation of a wheel-like component. The wheel begins with an initial angular velocity of $4\ rad/s$ and experiences a constant angular acceleration of $1\ rad/s^2$. Determine the time required for the wheel to complete 10 revolutions. **[4]**

b) Define a moment of inertia. **[2]**

c) A system of three particles of masses $m_1 = 0.5\ kg$, $m_2 = 1\ kg$, and $m_3 = 1.5\ kg$ are located in the xoy plane as shown in **Figure 4.1**. The particles are connected by rigid rods of negligible mass. Calculate the moment of inertia of the system:

i) about the x axis **[2.5]**

ii) about the y axis **[2.5]**

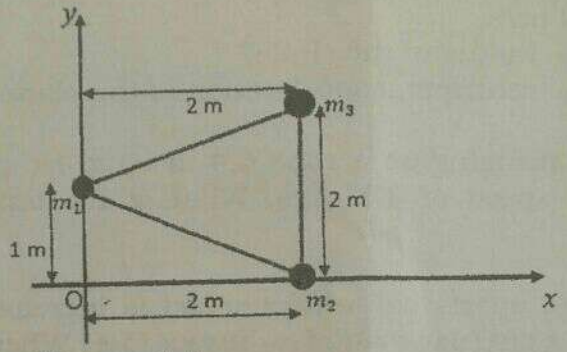


Figure 4.1

d) A wheel of radius $R = 0.4$ m, and moment of inertia $I = 0.48\ kgm^2$ is mounted on a frictionless horizontal axle, as in **Figure 4.2**. A rope of negligible mass wrapped around the wheel supports an object of mass $m = 3\ kg$. Calculate the **angular acceleration** of the wheel, the **linear acceleration** of the object, and the **tension** in the cord. **[8]**

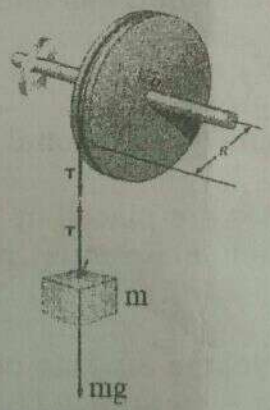
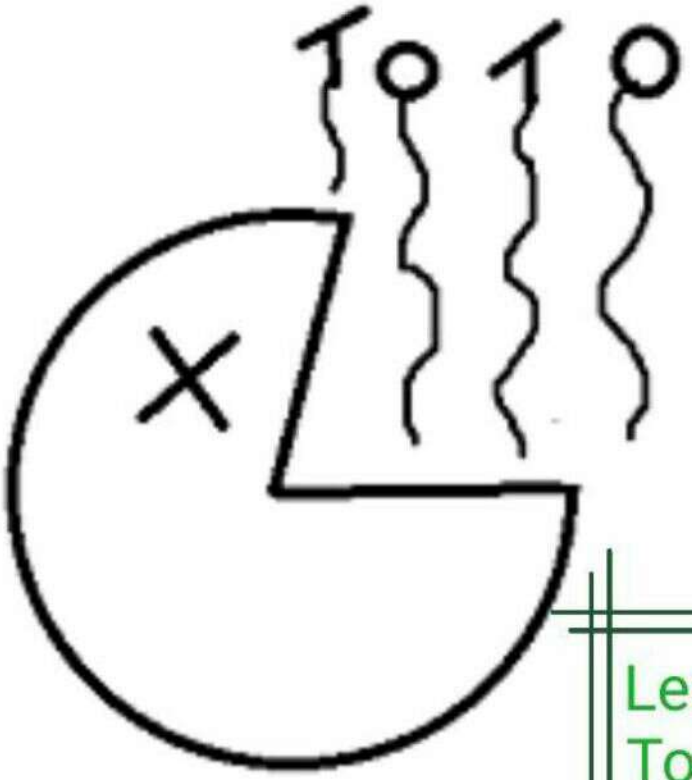


Figure 4.2

e) A $0.5kg$ uniform sphere of 5.0 cm radius spins at 1800 rev/min on an axis through its center. Find its **rotational kinetic energy** and **angular momentum**. **[6]**



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SCHOOL OF MATHEMATICS & NATURAL SCIENCES

DEPARTMENT OF PHYSICS

PH 110: INTRODUCTORY PHYSICS 2021/2022 TEST 1

DURATION: 2½ HOURS **TOTAL MARKS**: 100 MARKS

Mr Mukuka Gulf

INSTRUCTIONS:

1. Write your Names, **Student Identification Number and Lecture Group** on the front page of your answer booklet and possibly your ID on all your scripts.
2. There are four (4) questions in this test; **ANSWER ALL.**
3. The marks for each question are shown in the square brackets [ ], show your working to avoid loss of marks.

CONSTANTS:

1. Acceleration due to gravity $g = 9.81\ m/s^2$
2. Gravitational constant $G = 6.673 \times 10^{-11}\ N.m^2.kg^{-2}$
3. Mass of the Earth $M_E = 5.98 \times 10^{24}\ kg$

Where necessary, use

1.0 inch =2.54 cm, 1.609 km= 1.0 miles, 7.48 gallons =0.0283 m^3, 1.0 cm^3=1.0 ml, 746 W = 1.0 horsepower, 1000 kg = 1.0 tones.

QUESTION ONE.

a) One gallon of paint, that is $3.78\times10^{-3}\,m^3$, covers an area of $25m^2$. What is the thickness of paint on the wall? Give your answer in 5 significant figures. **[3]**

b) A plate rectangular in form has a length $(21.4\pm0.3)cm$ and a width of $(8.8\pm0.2)cm$. Determine the values of the *best area* of the plate and its *uncertainty*. **[4]**

c) A mile is 1760 yards or 1609 meters or 5280 feet, and a fortnight is 14 days. In 1991, the Zambian athlete, Samuel Matete won an Olympic gold medal, in Zurich, Switzerland, when he represented Zambia in the $400m$ hurdles. His average speed was 8.5 meters per second.
Give his speed in: (i) kilometers per second; (ii) yards per hour; and (iii) feet per fortnight. **[6]**

$\left(\frac{m}{s}\right)^6 \left(\frac{mm}{L^3}\right) \left(\frac{m}{s^2}\right)^{-3}$

$\frac{m^6}{s^6} \times \frac{mass}{m^3} \times \frac{s^6}{m^3}$

(d) (i) What are the three limitations of dimensional analysis? [3]

(ii) Assuming that the mass M of the big stone that can be moved by the flowing Kafue River depends on 'v' the velocity, 'ρ' the density of water and 'g', the acceleration due to gravity. Use dimensional analysis to find an expression for M. [9]

QUESTION TWO

(a) Give ***two*** examples in each case of a

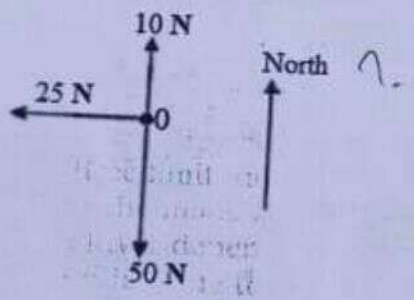
(i) scalar quantity [2]

(ii) vector quantity [2]

(b) Three boys are pulling an object with forces acting in different directions as shown in the diagram to the right:

(i) Draw a vector diagram and show the resultant force. [3]

(ii) Calculate the magnitude and direction of the resultant [5]



(c) For what value of λ are the vectors $2\mathbf{i} - \mathbf{j} + 2\mathbf{k}$ and $3\mathbf{i} + 2\lambda\mathbf{j}$ perpendicular? [4]

(d) If vector $\mathbf{a} = 2\mathbf{i} + 3\mathbf{j} + 4\mathbf{k}$, and vector $\mathbf{b} = \mathbf{i} - \mathbf{j} + \mathbf{k}$, Find

(i) $\mathbf{a} \times \mathbf{b}$ [3]

(ii) the Sine of the angle between these vectors. [3]

(iii) the Unit vector perpendicular to each vector. [3]

QUESTION THREE

(a) A runner travels 1.5 laps around a circular track in a time of 50 s. The diameter of the track is 45 m and its circumference is 142 m. Find :

(i) The average speed of the runner [3]

(ii) The magnitude of the runner's average velocity. [4]

(b) A particle moving along the x-axis has a displacement as a function of time given by:

$x(t) = 30 + 20t - 15t^2$, where x is in m and t is in s. Find:

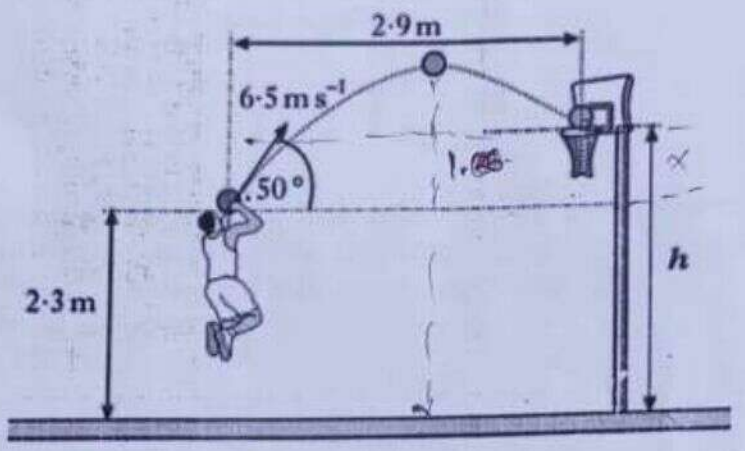
(i) The velocity at $t = 0.5$ s. [3]

(ii) The acceleration at $t = 3$ s. [4]

2 + 3 + 4

3

(c) A basketball player throws a ball with an initial velocity of 6.5 m/s at an angle of 50° to the horizontal. The ball is 2.3 m above the ground when released, and travels a horizontal distance of 2.9 m to reach the top of the basket. See the figure below (Not drawn to scale). The effects of air resistance can be ignored.



Find the

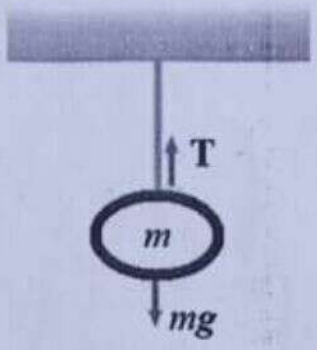
(i) horizontal and vertical components of the initial velocity of the ball. [2]
(ii) time taken by the ball to reach the basket. [3]
(iii) magnitude of the velocity of the ball as it reaches the top of the basket. [4]
(iv) height h as depicted from the figure. [4]

QUESTION FOUR

(a) Let 35° be the critical angle of an inclined plane on which a 10 kg block of wood slides down. Taking g = 9.81 m/s², determine the:

(i) Coefficient of static friction [2]
(ii) Static frictional force [2]

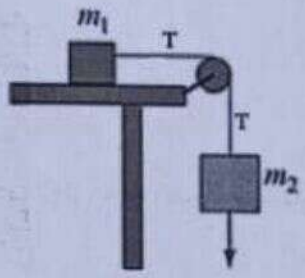
(b) Consider the diagram below with a 12 kg mass (m) vertically hanging on a rope that is attached to an upper platform. If the whole system accelerates upwards at 5.5 m/s², calculate the tension (**T**) in the rope. Take g = 9.81 m/s². [3]



(c) Two blocks of mass m_1 = 4 kg and m_2 = 10 kg are connected via a cord through the pulley as shown. The coefficient of kinetic friction between m_1 and the table is 0.2. Taking g = 9.81 m/s², determine the,

(i) Acceleration of the system [4]

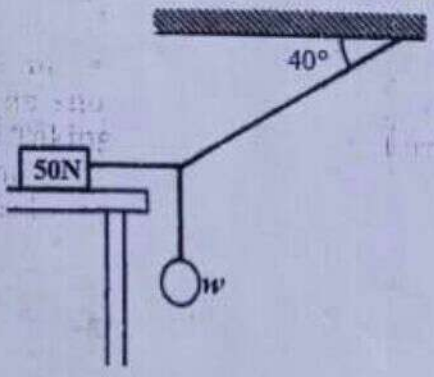
(ii) Tension in the cord. [2]



(d) The system shown in the Figure below is in equilibrium.

(i) Determine the maximum value of w if the friction force on the 50 N block cannot exceed 15 N. [9]

(ii) What is the coefficient of static friction between the block and the table top? [3]



THE COPPERBELT UNIVERSITY

SCHOOL OF MATHEMATICS & NATURAL SCIENCES

DEPARTMENT OF PHYSICS

PH 110: INTRODUCTORY PHYSICS 2021/2022 TEST 2
DURATION: 2 HOURS **TOTAL MARKS:** 100 MARKS

INSTRUCTIONS:

1. Write your Names, **Student Identification Number and Lecture Group** on the front page of your answer booklet and possibly your ID on all your scripts.
2. There are **four (4)** questions in this test; **ANSWER ANY THREE (3).**
3. The marks for each question are shown in the square brackets [ ], show your working to avoid loss of marks.

CONSTANTS:

1. Acceleration due to gravity $g = 9.8\ m/s^2$
2. Gravitational constant $G = 6.673 \times 10^{-11}\ N.m^2.kg^{-2}$
3. Mass of the Earth $M_E = 5.98 \times 10^{24}\ kg$

Where necessary, use

746 W = 1.0 horsepower, 1000 kg = 1.0 tonne.

QUESTION ONE.

(a) Starting from rest, a 5.00 kg block slides 2.50 m down a rough 30.0° incline. The coefficient of kinetic friction between the block and the incline is $\mu = 0.40$

Determine,

(i) the work done by the force of gravity, [3]

(ii) the work done by friction force between block and incline, [3]

(iii) the final velocity at the bottom of the incline [3]

(b) With the aid of an equation, state the:

[2]

(i) conservation of mechanical energy [2]

(ii) work – energy theorem

(c) Fig.1.1 shows a bead sliding on a wire. If the friction force are negligible and the bead has a speed of 100 cm/s at A, what will be its speed in SI units at, [3, 3]
(i) point B? (ii) point C?

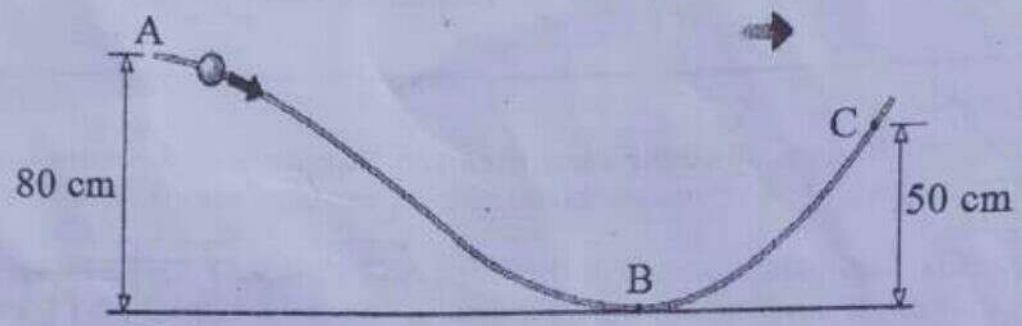


Fig.1.1

(d) At what average speed would a 70 kg student have to climb a 5 m rope to match with the power output of a 150 W light bulb? [3]

(e) A force $\mathbf{F}=(5\mathbf{i}+2\mathbf{j}-5\mathbf{k})N$ acts on a particle that undergoes displacement $\nabla\mathbf{r}=(2\mathbf{i}+3\mathbf{j}+4\mathbf{k})\,m$. Find the work done by the force on the particle. [3]

QUESTION TWO

(a) Define **linear momentum**, **elastic collision** and **inelastic collision**. [2, 2, 2]

(b) State the law of conservation of linear momentum. [2]

(c) A tennis ball of mass 40 g, moving to the right with a speed of 5 m/s, has an elastic collision with a target ball of mass 60 g that was at rest. What is the velocity of each ball after the collision? [7]

(d) A car of mass 800 kg travelling due north collides with a truck of mass 2000 kg travelling due east. After an investigation by the traffic police, it was determined that the truck was travelling at 36 km/h before the collision. After the collision the car and the truck stick together and move in the direction 53° North of East. Neglecting friction, determine

(i) their common speed after the impact [5]
(ii) the velocity of the car before the collision [5]

QUESTION THREE

(a) A Physics lecturer swings a rubber stopper in a horizontal circle at the end of a string in front of his class. He tells Zuba, in the first row, that he is going to let the string go when the stopper is directly in front of her face. Will the stopper hit Zuba's face or not? [3]

(b) A one-ton car rounds an unbanked curve of radius 50 m at a speed of 50.4 km/h. Will the car follow the curve or skid in the following scenarios:
(i) Where the pavement is dry and the coefficient of the static friction is $\mu, = 0.55$ [4]

(ii) Where the pavement is icy and the coefficient of static friction is $\mu_s = 0.24$. [3]

(c) The mass of the Earth is 5.97×10^{24} kg, the mass of the Moon is 7.35×10^{22} kg, and the mean distance of the Moon from the center of the Earth is 3.84×10^5 km. Use these data to calculate the magnitude of the gravitational force exerted by Earth on the Moon. [3]

(d) State Keplers's three Laws of Planetary motion [6]

(e) (i) Derive the relationship between the period of the planet, the radius of its orbit and the mass of the Sun. [3]

(ii) The planet Mercury travels around the Sun with a mean orbital radius of 5.8×10^{10} m. The mass of the Sun is 1.99×10^{30} kg. How long does it take Mercury to orbit the Sun. [3]

QUESTION FOUR

(a) The angular velocity of a rotating disk with a radius of 2 m decreases from 6 rads per second to 3 rads per second in 2 seconds. What is the linear acceleration of a point on the edge of the disk during this time interval? [4]

(b) A solid sphere of radius 0.2 m and mass 2 kg is at rest at a height 7 m at the top of an inclined plane making an angle 60° with the horizontal. Assuming no slipping, what is the speed of the solid sphere at the bottom of the incline? Take Moment of Inertia of a solid sphere to be $\frac{2}{5}mr^2$. [7]

(c) A solid, uniform, frictionless cylindrical **disc** ($I_{disc} = \frac{1}{2}mr^2$) of mass M = 3.00 kg and radius R = 0.40 m is used to draw water from a well as shown in Figure 4.1. A bucket of mass m = 2.00 kg is attached to a cord that is wrapped around the disc.

(i) Sketch free body diagrams for the disc and for the bucket, [2]

(ii) Find the acceleration of the bucket. [4]

(iii) Find the tension *(T)* in the cord. [5]

(iv) If the bucket starts from rest at the top of the well and falls for 3.00 s before hitting the water, how far does it fall? [3]

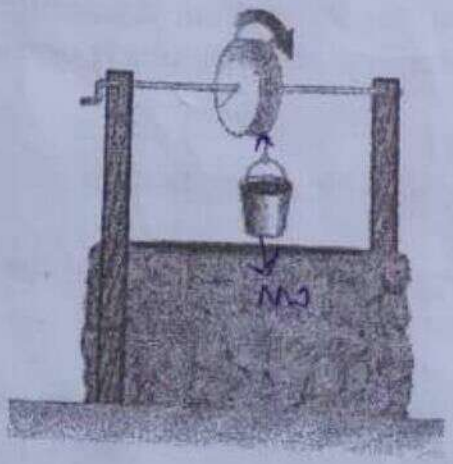


Figure 4.1: Cylindrical Disc and bucket for drawing water.

THE COPPERBELT UNIVERSITY

SCHOOL OF MATHEMATICS & NATURAL SCIENCES

2021/2022 SESSIONAL EXAMINATION

PH 110: INTRODUCTORY PHYSICS

DURATION: 3 HOURS **TOTAL MARKS**: 100 MARKS

INSTRUCTIONS:

1. Write your **Student Identification Number** on the answer Booklet provided.
2. This examination question paper contains **nine (9)** printed pages, and **seven (7)** questions.
3. Answer any **FIVE (5)** questions from this examination paper.
4. Each question carries **twenty (20)** marks. The relative allocation of marks in each part-question is indicated on the right-hand margin.
5. Show all your working on the answer booklet provided.
6. An answer without a unit gets no marks.

You may not start to read the questions printed on the subsequent pages on this question paper until instructed to do so by the invigilator.

[PLEASE TURN OVER]

LIST OF PHYSICAL CONSTANTS

Acceleration due to gravity	g	$9{\cdot}81\ \text{m s}^{-2}$
Electronic charge	e	$1{\cdot}602 \times 10^{-19}\ \text{C}$
Gravitational constant	G	$6{\cdot}672 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$
Permeability of vacuum	μ_0	$4\pi \times 10^{-7}\ \text{H m}^{-1}$
Permittivity of vacuum	ε_0	$8.85 \times 10^{-12}\ \text{F m}^{-1}$
Mass of the Earth	M_E	$5.98 \times 10^{24}\ \text{kg}$
Mass of the Sun	M_S	$1.99 \times 10^{30}\ \text{kg}$
Radius of the Earth	R_S	$6.4 \times 10^{6}\ \text{m}$
Moment of Inertia of Disc	I_{disc}	$\frac{1}{2}mr^2$
Moment of Inertia of Cylinder	Icy	$\frac{2}{5}mr^2$
Moment of Inertia	I	$\sum_{i=1}^{i=n} mr^2$

QUESTION ONE

(a) Define the following terms as they are used in Physics: (i) **physical quantity**, (ii) **least count** of a measuring instrument. **[1, 1]**

(b) According to the label on a bottle of "big" Manzi Valley water, the volume of the contents is 750 mL. Using only the conversion $1\,L = 1000\,cm^3$ and $1\,inch = 2.54\,cm$, express this volume in cubic inches. **[2]**

(c) A mile is 1760 yards or 1609 metres or 5280 feet, and a fortnight is 14 days. In 2022, the Zambian track and field sprinter, Muzala Samukonga, won a gold medal at the 2022 Birmingham Commonwealth Games, when he represented Zambia in the 400 metres. His average speed was 8.96 metres per second. Give his speed: (i) kilometre per second; (ii) yard per hour; and (iii) feet per fortnight. **[2, 2, 2]**

(d) A ship is steaming due east at a speed of $12\,m/s$. A passenger runs across the deck at a speed of $5\,m/s$ toward north. What is the resultant velocity of the passenger relative to the sea? **[3]**

(e) Vectors $\vec{A}$ and $\vec{B}$ have scalar product -6.0 and their vector (cross) product has magnitude $+9.0$. What is the angle between these two vectors? **[7]**

QUESTION TWO

a) Define Projectile Motion. **[2]**

b) A projectile is fired horizontally with a velocity of 98 ms^{-1} from the top of a hill 500 m high. Find

(i) the time taken for the projectile to reach the ground **[3]**

(ii) the distance of the target from the hill **[2]**

(iii) the velocity with which the projectile hits the ground **[3]**

c) A car is accelerating uniformly as it passes two check points that are 60 m apart. The time taken between the check points is 5.0 s and the car's speed at the first checkpoint is 10 m/s. Calculate the car's **acceleration** and its **speed** at the second check point. **[3, 2]**

d) An electron traveling with a speed of 5×10^3 ms^{-1} passes through an electric field with an acceleration of 10^{12} ms^{-2}. Calculate the distance an electron would cover if its speed is doubled? **[5]**

QUESTION THREE

(a) Which of Newton's Laws of motion is sometimes referred to as the law of inertia? What does it state? **[3]**

(b) A ball of mass $m_1 = 1$ kg and a block of mass $m_2 = 5$ kg are attached by a lightweight cord that passes over a frictionless pulley of negligible mass, as shown in **Figure 3.1**. The block lies on a rough incline of angle $\theta = 30°$. The coefficient of kinetic friction between the block and the incline is 0.3. Find

(i) the acceleration of the two objects. **[7]**

(ii) the tension in the cord. **[2]**

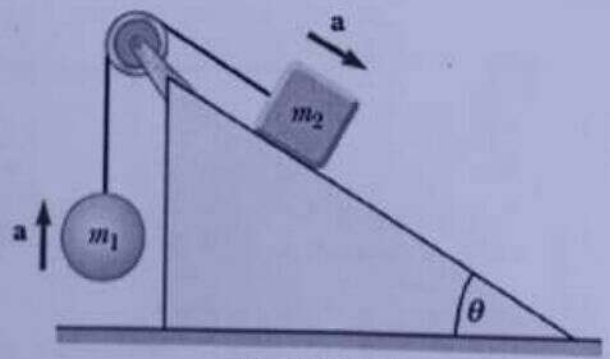


Figure 3.1

(c) A traffic light weighing 100 N hangs from a cable tied to two other cables fastened to a support, as shown in **Figure 3.2**. The upper cables make

angles of 37.0° and 53.0° with the horizontal. If the system is in equilibrium, find the tensions T_1, T_2, and T_3 in the cables. [8]

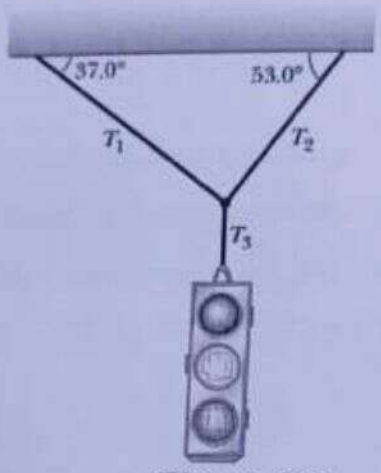


Figure 3.2

QUESTION FOUR ✓

(a) A bullet of mass 15 g and travelling at a speed of 600 m/s strikes a block of mass 3 kg which is suspended by a string of length 4 m. The bullet goes through the block in a very short time and the centre of gravity of the block is found to rise a vertical distance of 10 cm as shown in **Figure 4.1**. What is the speed of the bullet just after it emerges from the block? **[10 marks]**

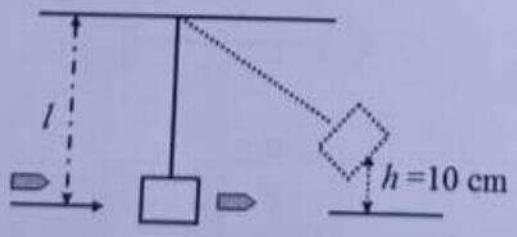


Figure 4.1

(b) A bullet of mass 0.02 kg travelling at a speed of 100 m/s comes to rest when it has gone 0.4 m into sand. Find the resisting force exerted by the sand. **[4]**

(c) You are standing in a room that is 3.00 m high from the floor to the ceiling. A table top is 1.10 m above the floor. A 3 kg sack of sugar is on the table top. What is the gravitational potential energy (GPE) of the sack relative to: (i) the floor (ii) the table top and (iii) the ceiling? **[2, 2, 2]**

QUESTION FIVE

(a) A cylindrical wheel with the moment of inertia I = 750 kg.m^2 is spinning at 21 rev/min when a mechanism is engaged that causes a cord on the rim to lift a 10 kg mass as the wheel comes to rest. How high can the wheel lift the mass? Neglect any change in rotational kinetic energy during the engagement. **[4]**

(b) Define the moment of inertia of an object or system. **[2]**

(c) The four particles in **Figure 5.1** are connected by the rigid rods of negligible mass. The origin is at the centre of the rectangle *0* and the *z*-axis passes through *0* and is normal to the *x0y* plane. If the system rotates in the *xy* plane about the *z* axis with an angular velocity of 8 rad/s, calculate:

(i) the moment of inertia of the system about the *z* axis. **[4]**

(ii) the kinetic energy of the system. **[2]**

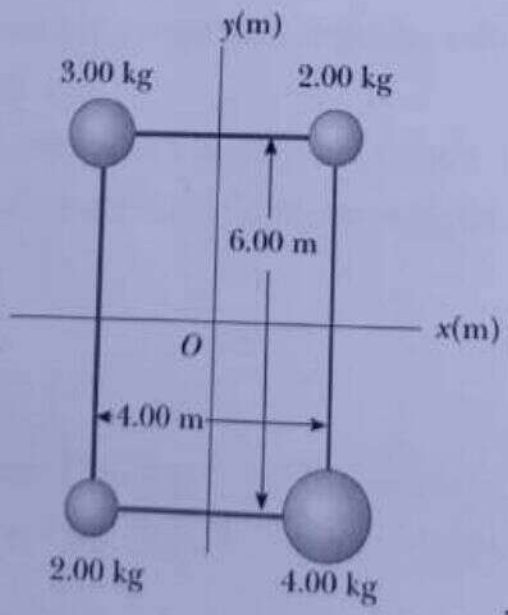


Figure 5.1

(d) A 200-g block connected to a light spring for which the force constant is 5.00 N/m is free to oscillate on a horizontal, frictionless surface. The block is displaced 5.00 cm from equilibrium and released from rest.

(i) Find the period of its motion. [2]

(ii) Determine the maximum speed of the block. [2]

(iii) What is the maximum acceleration of the block? [2]

(iv) Express the position and speed as functions of time. [2]

QUESTION SIX

(a) A race car in moving on a road that has a banked curve with 31.0° tilt and with radius of 316 m and negligible friction.

(i) Calculate the speed of the race car. [2]

(ii) Find the necessary centripetal acceleration on this curve so that the car won't tend to slip down or slide up the incline. [5]

(iii) If the banking above was changed to the radius of 245 m, what should be the angle of the bank to allow safe travel around the curve at 58.0 m/s? [3]

(b) Define the following for an object:

(i) Gravitational potential energy with respect to infinity [2]

(ii) Gravitational field [2]

(c) If a satellite leaves the earth's surface at escape speed of $11.2 \times 10^3\ m/s$, at what speed is it moving when $1.50 \times 10^5\ km$ from the center of Earth? Neglect any friction effects. [6]

QUESTION SEVEN ✓

(a) Two point charges, Q_1 and Q_2, at a distance 3 m apart, are shown in **Figure 7.1**. The charge on Q_1 is - 14 μC and the charge on Q_2 is + 20 μC.

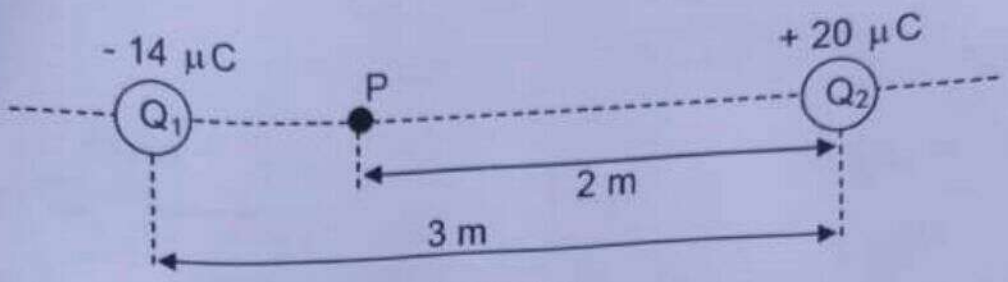


Figure 7.1

(i) Define what is meant by the term electric field. [1]

(ii) Draw the electric field pattern due to these two charges. [2]

(iii) Calculate the net electric field at point P situated 2 m from Q2. [3]

(b) The diagram in **Figure 7.2,** shows a 12 V battery having an unknown internal resistance **r** connected to a light bulb of resistance 5 Ω and two resistors of resistance 15 Ω and 10 Ω each. The ammeter reads 1 A.

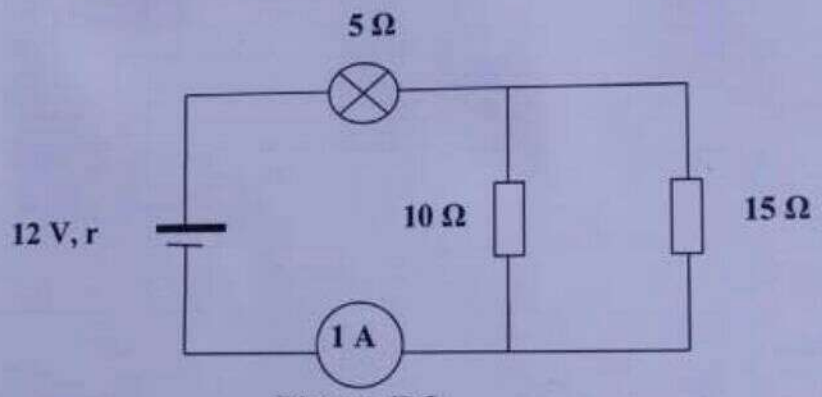


Figure 7.2

(i) Find the total external resistance of the circuit. [2]

(ii) Calculate the internal resistance of the battery. [2]

(iii) Find the heat generated in the 15 Ω resistor in 2 minutes [2]

(c) The circuit diagram below consists of three batteries of negligible internal resistance:

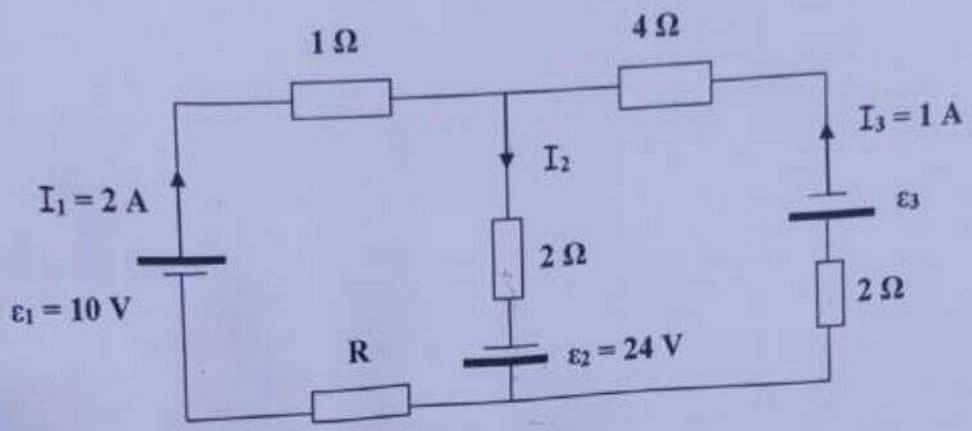


Figure 7.3

Use Kirchoff's laws to determine:

(i) the current I_2; [2]
(ii) the resistance R; [3]
(iii) the emf ε_3. [3]

[END OF EXAMINATION PAPER]

THE COPPERBELT UNIVERSITY
SCHOOL OF MATHEMATICS AND NATURAL SCIENCES
DEPARTMENT OF PHYSICS

PH 110: Introductory Physics

TEST 1 **DATE: 11th MARCH 2021** **TIME: 2 hours**

INSTRUCTIONS: There are three (3) questions in this paper each carry 25 marks, answer **ALL.** Write down your **names**, **computer number** and **lecture group** on the front page of your answer booklet.

Where necessary use the following: $g = 9.8\ \text{m/s}^2$, **2.54 cm = 1 inch, 1.609 km = 1 mi, 1 ton = 1000 kg,**

Question One

(a) The mass of the parasitic wasp can be as small as 5×10^{-6} kg. What is this mass in (i) grams (g) (ii) milligrams (mg) (iii) micrograms (μg) **[6]**

(b) State the number of significant figures in the following :
(i) 0.006 m^2 (ii) 0.2309 m^3 (iii) 0.006032 kg (iv) 2.75×10^3 kg **[2]**

(c) If velocity (V), time (T) and force (F) were chosen as basic quantities, find the dimensions of mass. **[3]**

(d) The time dependence of a physical quantity P is found to be of the form $P = P_0 e^{-\alpha t^2}$, where t is the time and α is some constant. What are the dimensions of α? **[2]**

(e) (i) state two applications of dimensional analysis **[2]**
(ii) The period of oscillation of a simple pendulum is assumed to depend on its length (l), mass of the bob (m) and acceleration due to gravity (g). Using dimensional analysis, derive its time period (T). **[8]**
(iii)Write down two limitations of dimensional analysis **[2]**

Question Two

(a) A child obviously lost, walks 75 m at 25° north of east, then 100 m at 15° south of east, then 90 m south and finally 50 m 30° north of west. Choose the y-axis pointing north and the x-axis pointing east, and find:
(i) the total distance covered by the child.
(ii) the magnitude and direction of the resultant displacement of the child. **[10]**

(b) Given two vectors ***A*** and ***B*** where $\mathbf{A} = i + 2j + 3k$ and $\mathbf{B} = 3i + 2j + 3k$. Calculate the following:

(i) $\mathbf{A} \times \mathbf{B}$ **[3]**
(ii) The angle between ***A*** and ***B***. **[3]**
(iii) Determine the unit vector perpendicular to $\mathbf{A} \times \mathbf{B}$. **[2]**

(c) A force $\mathbf{F} = 2\mathbf{i} + 3\mathbf{j} + 4\mathbf{k}$ pushes an object of mass 5 kg from the origin to a position vector $\mathbf{r} = 3\mathbf{i} - 2\mathbf{j} + 5\mathbf{k}$. Using the scalar product of vectors, determine the work done by the force on the object. [5]

Question Three

a) Briefly discuss how average speed compares with average velocity **[3].**

b) A ZAF Officer fires a bullet that moves along the x axis. Its velocity as a function of time is expressed as $v(t) = 4 + 8t$, where v is in m/s. The position of the bullet at $t = 1s$ is $25m$. Determine:

(i) The acceleration at $t = 2s$ **[2]**

(ii) The position at $t = 1.5s$ **[3]**

c) A teargas canister thrown vertically upward is held by a student after $2.0s$. Determine:

(i) The speed with which the teargas canister was thrown **[2]**

(ii) The maximum height the teargas canister reaches. **[2]**

(d) A golfer chooses a 7-iron club to 'chip' the ball a short distance onto the green. His shot gives the ball a velocity of 15 $m.s^{-1}$ at an angle of 35^0 to the horizontal. *(Ignore air resistance for the following calculations.)*

(i) What are the horizontal and vertical components of the ball's velocity just after it is hit? **[4]**

(ii) How long will the ball take to reach its maximum height? **[2]**

(iii) Measured along the ground, how far will the ball have travelled when it hits the ground (i.e. what is its horizontal range?). **[4]**

(iv) How would this range change if this shot had been played on the Moon? Make sure to explain why it would change. **[3]**

THE COPPERBELT UNIVERSITY

PHYSICS DEPARTMENT

SCHOOL OF MATHEMATICS AND NATURAL SCIENCES

DEFERRED TEST 1

COURSE: PH 110 **APRIL 2021**

ANSWER ALL QUESTIONS **TIME: TWO (2) HOURS**

QUESTION ONE

(a) Convert the following:

i. 100 mg into kg [2]

ii. 0.005 N into cgs system [2]

iii. 0.1 cm^2 into m^2 [2]

iv. 0.1 liters into cm^3 [2]

v. 2.5×10^{-10} m into μm [2]

(b) State two (2) advantages of using the method of Estimations and Order of Magnitude in calculations. [2]

(c) State two (2) disadvantages of using the method of Estimations and Order of Magnitude in calculations. [2]

(d) Given the vectors $\boldsymbol{A} = 5\hat{i} + 3\hat{j} + 2\hat{k}$ and $\boldsymbol{B} = -4\hat{i} + 4\hat{j} + 7\hat{k}$. Find the angle between vectors $\boldsymbol{A}$ and $\boldsymbol{B}$ [5]

(e) A car initially at point X moves at constant velocity for 0.5 km eastward for 10 minutes to reach point Y and after point Y it suddenly changes to a constant velocity to move another 2 km eastward for 5 minutes to reach point Z.

(i) Calculate the average velocity in SI units for the scenario [3]

(ii) Calculate acceleration of the car from X to Z. [3]

QUESTION TWO

(a) Given that the three vectors $\boldsymbol{A} = 2\hat{\imath} + 3j - 2k$, $\boldsymbol{B} = -4i + 3j + 7k$ and $\boldsymbol{C} = -i\hat{} + 4j + 9k$ act at one point in space. Find:

(i) The resultant vector [6]

(ii) The magnitude of the resultant vector [4]

(iii) The unit vector of the resultant [4]

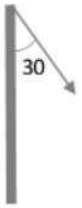
(iv) The direction of the resultant with respect to the x-axis [4]

(b) Given the vectors $\boldsymbol{A} = 2i\hat{} + 3j\hat{} - 2k$, $\boldsymbol{B} = -4i\hat{} + 3j\hat{} + 7k$ and $\boldsymbol{C} = -i\hat{} + 4j\hat{} + 9k$.

Find the scalar triple product **A**.(**B** x **C**) [7]

QUESTION THREE

(a) A projectile is fired downwards with an initial velocity of 30 m/s at 30° angle to the vertical (as shown) and hits the ground after 10 s. Use g = 9.82 m/s^2



Calculate:

(i) The final velocity on impact [4]

(ii) The height from which the projectile was fired [4]

(iii) The range of the projectile [3]

(iv) The x-component of the acceleration [2]

(b) A projectile is fired upward (vertically). It takes 30 seconds to come back to its starting point. Calculate:

(i) The maximum possible height reached [4]

(ii) The initial velocity [3]

(iii) The velocity halfway upwards [3]

(iv) Give one reason why in practice the time of ascent may be different from time of descent in projectile motions [2]

SOLUTION-QUESTION ONE

(a)

i. 1g = 1kg/1000 = 10^{-3} kg; 1mg = 1kg/1,000,000 = 10^{-6} kg; 100mg => 10^{-4} kg [2]

ii. 0.005 N = 0.005 kg.m/s^2 = 0.005 (1000)g(100)cm/s^2 = 100 g.cm/s^2 [2]

iii. 1cm = 10^{-2}m; 1cm^2 = $10^{-4}m^2$; 0.1cm^2 = $10^{-4}m^2$ x $10^{-1}cm^2$ = 10^{-5} m^2 [2]

iv. 1 L = 1000cm3; 0.1 L = 100 cm3 [2]

v. 2.5 x 10^{-10} m = 2.5 x 10^{-6} x10^{-4} m = 2.5 x 10^{-4} μm [2]

(b) - Estimates serve as a partial check if the exact calculations are correct.
- Calculations can be carried out where limited information is available
- Can be used where it is difficult or impossible to get an exact answer in a calculation [2]

(c) - It does not give precise answers

- Values close to each other cannot easily be estimated apart [2]

(d) Given the vectors $\boldsymbol{A} = 5\hat{i} + 3\hat{j} + 2\hat{k}$ and $\boldsymbol{B} = -4\hat{i} + 4\hat{j} + 7\hat{k}$. Find the angle between vectors ***A*** and ***B*** [5]

A.**B** = |**A**| |**B**|cosθ; cosθ = **A**.**B**/ |**A**| |**B**|; θ = $\cos^{-1}$ (**A**.**B**/ |**A**| |**B**|)

But, **A**.**B** =5(-4) + 3(4) + 2(7) = -20 + 12 + 14 = **6**;

$|\mathbf{A}| = \sqrt{5^2 + 3^2 + 2^2} = \sqrt{38}$

$|\mathbf{B}| = \sqrt{(-4)^2 + 4^2 + 7^2} = \sqrt{81}$

Also $\sqrt{38}x\sqrt{81} = \mathbf{55.48}$

Hence θ = $\cos^{-1}$ (6/55.48); θ = $\cos^{-1}$ (0.108147); θ = $\cos^{-1}$ (0.108147) = 83.79°

(e) A car initially at point X moves at constant velocity for 0.5 km eastward for 10 minutes to reach point Y and after point Y it suddenly changes to a constant velocity to move another 2 km eastward for 5 minutes to reach point Z.

(i) average velocity:

$$u = 0.5km/10\,\text{min} = \frac{500m}{600s} = 0.833\,m/s$$

$$v = 2km/5\,\text{min} = \frac{2000m}{300s} = 6.667\,m/s$$

Average velocity = (v+u)/2 = (6.667 + 0.833)/2 = 7.5 m/s [3]

(ii) acceleration from X to Z:

Acceleration = (v-u)/t; Acceleration = (6.667-0.833)/900= 6.48 x 10^{-3} m/s^2; [3]

SOLUTION - QUESTION TWO

(a) vectors $\boldsymbol{A} = 2\hat{\imath} + 3j - 2k$, $\boldsymbol{B} = -4i + 3j + 7k$ and $\boldsymbol{C} = -i + 4j + 9k$

(i) The resultant vector **R**:

$\mathbf{R} = \mathbf{A} + \mathbf{B} + \mathbf{C} = (2-4-1)\,i + (3+3+4)\,j + (-2+7+9) = -3i + 10j + 14k$ [6]

(ii) magnitude of **R**: $R = \sqrt{(-3)^2 + 10^2 + 14^2} = \sqrt{305} = 17.46$ [4]

(iii) Unit vector of **R**: $\hat{R} = \frac{\boldsymbol{R}}{R} = \frac{-3\mathrm{i} + 10\mathrm{j} + 14\mathrm{k}}{17.46}$ [4]

(iv) direction of **R**: Tan(θ) = 10/3 = 3.333; θ = Tan^{-1}(3.333)= 73.3° [4]

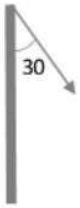
(b) Find the scalar triple product **A**.(**B** x **C**) :

$$(\mathrm{B \times C}) = \begin{vmatrix} 2 & 3 & -2 \\ -4 & 3 & 7 \\ -1 & 4 & 9 \end{vmatrix} = 2(3x9 - 7x4) - 3(-4x9 + 1x7) - 2(-4x4 + 1x3)$$

$$= -2 + 87 + 26 = 111$$ [7]

SOLUTION - QUESTION THREE

(a) A projectile is fired downwards with an initial velocity of 30 m/s at 30° angle to the vertical (as shown) and hits the ground after 10 s. Use g = 9.82 m/s^2



(i) The final velocity on impact

$u_y = 30\cos(30) = 25.981 m/s; \qquad u_x = 30\sin(30) = 15 m/s;$

$v_y = u_y + a_y t = 25.981 + 9.82(10) = 124.181 m/s$

$v_x = u_x + a_x t = 15 + 0(10) = 15 m/s$

$v = \sqrt{{v_y}^2 + {v_x}^2} = \sqrt{124.181^2 + 15^2} = 125.08\ m/s$ [4]

(ii) The height from which the projectile was fired

${v_y}^2 = {u_y}^2 + 2a_y S_y \quad ; S_y = \frac{{v_y}^2 - {u_y}^2}{2a_y} = (124.181^2 - 25.981^2)/2(9.82)$

$= (15420.928 - 675.012)/19.64 = 14745.916/19.64 = 750.81\ m$ [4]

(iii) The range of the projectile

$S_x = \frac{(v_x+u_x)t}{2} = \frac{2v_x t}{2} = v_x t = 15(10) = 150\ m$ [3]

(iv) x-component of the acceleration $= 0\ m/s^2$ due to constant velocity [2]

(b) A projectile is fired upward (vertically). It takes 30 seconds to come back to its starting point. Calculate:

(i) The maximum possible height reached:

Time taken to go up is 30/2= 15 s; $v_y = u_y + a_y t \Rightarrow 0 = u_y - 9.82(15)$

$u_y = 9.82(15) =$

$S_y = \frac{(v+u)t}{2} = \frac{(0+u)15}{2} = \frac{15u}{2} = \frac{9.82(15)(15)}{2} =$ [4]

(ii) The initial velocity

$u_y = 9.82(15) =$ [3]

(iii) The velocity halfway upwards

$v = \frac{u_y}{2} = \frac{9.82(15)}{2} =$ [3]

(iv) Give one reason why in practice the time of ascent may be different from time of descent in projectile motions: Air resistance [2]

THE COPPERBELT UNIVERSITY

SCHOOL OF MATHEMATICS & NATURAL SCIENCES

2020/2021 SESSIONAL EXAMINATION

PH 110: INTRODUCTORY PHYSICS

DURATION: 3 HOURS **TOTAL MARKS:** 100 MARKS

INSTRUCTIONS:

1. Write your **Student Identification Number** on the answer Booklet provided.
2. This examination question paper contains **NINE (9)** printed pages, and **seven (7)** questions.
3. Answer any **FIVE (5)** questions from this examination paper.
4. Each question carries **twenty (20)** marks. The relative allocation of marks in each part-question is indicated on the right-hand margin.
5. Show all your working on the answer booklet provided.
6. An answer without a unit gets no marks.
7. Where applicable, give your answer correct to **3 significant figures**

You may not start to read the questions printed on the subsequent pages on this question paper until instructed to do so by the invigilator.

[PLEASE TURN OVER]

LIST OF PHYSICAL CONSTANTS

Acceleration due to gravity	g	$9{\cdot}80\ \text{m s}^{-2}$
Electronic charge	e	$1{\cdot}602 \times 10^{-19}\ \text{C}$
Gravitational constant	G	$6{\cdot}672 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$
Permeability of vacuum	μ_0	$4\pi \times 10^{-7}\ \text{H m}^{-1}$
Permittivity of vacuum	ε_0	$8.85 \times 10^{-12}\ \text{F m}^{-1}$
Electron (rest) mass	m_e	$9.11 \times 10^{-31}\ \text{kg}$
Proton (rest) mass	m_p	$1.67 \times 10^{-27}\ \text{kg}$
Neutron (rest) mass	m_n	$1.67 \times 10^{-27}\ \text{kg}$

QUESTION ONE

a) A car starts from rest and accelerates at 4 m/s² through a distance of 20 m.

(i) How fast is it moving? [2]

(ii) How long has it taken to cover a 20 m distance [2]

b) A stray dog moving with constant acceleration covers a distance of 70 m between points A and B in 7 seconds. Its speed as it passes point B is 15 m/s. What is its acceleration? [4]

c) A ball is thrown vertically upward from the ground to a height of 0.44 m, determine its initial speed as it leaves the ground and how long does it take in the air? [4]

d) A bullet is fired from the a level ground with an initial velocity of 80 m/s at an angle 60° above the horizontal without appreciable air resistance.

(i) Find the horizontal and vertical components of the bullet's initial velocity. [2]

(ii) How long does it take the bullet to reach its highest point? [2]

(iii) Find its maximum height above the ground. [2]

(iv) How far from its firing point along the horizontal does the bullet land? [2]

QUESTION TWO

a) The two masses in Figure 2.1 are tied to the ends of a massless rope and the rope is hung over a massless and frictionless pulley. Given that $m_1 = 4\,\text{kg}$ and $m_2 = 6\,\text{kg}$, determine the following:

(i) The acceleration of the masses. [6]

(ii) The tension in the rope. [3]

(iii) How long will it take mass m_2 to fall a distance of 0.98 m after the system is released. [3]

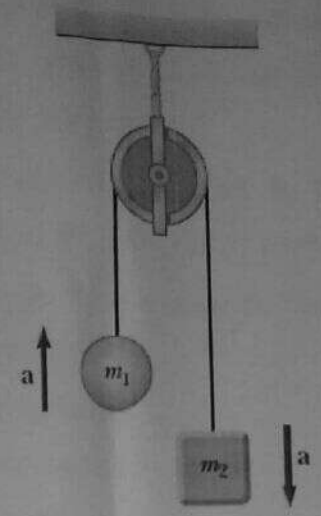


Figure 2.1

b) A box of mass 5 kg is pulled with a force of 25 N as shown in Figure 2.2. Assume that there is no friction force to impede the motion. Answer the questions following:

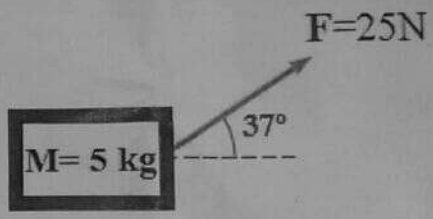


Figure 2.2

(i) State Newton's First and Second laws of motion. **[2]**
(ii) Calculate the acceleration of the box. **[3]**
(iii) Determine the reaction force $\vec{R}$ (normal force) that the ground exerts on car. **[3]**

QUESTION THREE

(a)

(i) Round off 0.00349 to 3 decimal points **[1]**

(ii) Find the number of significant figures in 30200 **[1]**

(iii) Convert 5×10^{-6} Joules to the equivalent cgs system **[2]**

$F = mg$

(i) Write down two applications of dimensional analysis. [2]

(ii) Using dimensional analysis, show that the equation of motion given by $v^2 = u^2 + 2as$ is dimensionally correct [2]

(c) In Figure 3.1 below four vectors $\vec{A} = 15\,\text{N}, \vec{B} = 8\ \text{N}, \vec{C} = 10\,\text{N}$ and $\vec{D} = 12$ that make angles with the horizontal of 0°, 10°, 100° and 160° respectively. Their resultant vector is represented by $\vec{R}$. Use a table to find the:

(i) x-component of the resultant. [4]

(ii) y-component of the resultant. [4]

(iii) magnitude of the resultant. [2]

(iv) direction of the resultant. [2]

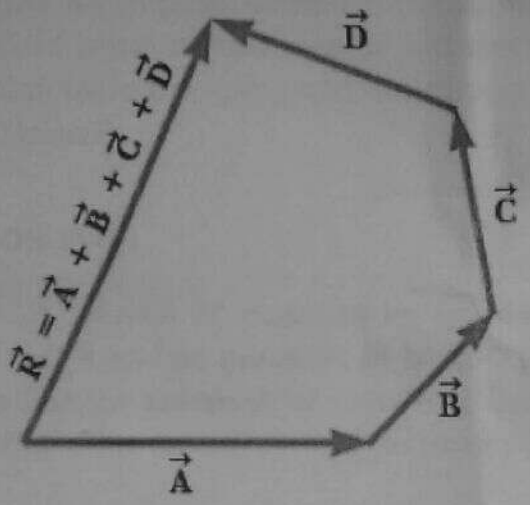
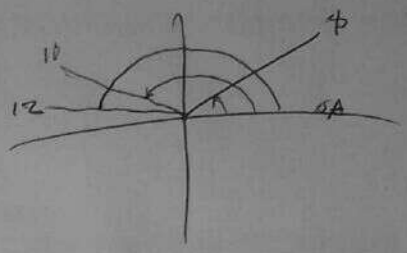


Figure 3.1



$V^2 = u^2$

$MT^{-1} = MT^{-1}$

$LT^{-1} = LT^{-1}$

$V = 2as$

$LT^{-1} = 2LT^{-2}$

QUESTION FOUR

(a) A force $F = (9x + 8)$ N acts on a particle in the x direction, where F is in newton and x in meter. Find the work done by this force during a displacement from $x = 0$ to $x = 3$. [3]

$KE = F \times d$

$(9x+8)(3-x) =$

(b) (i) State the law of conservation of energy. [1]

(ii) In Figure 4.1, a bead is sliding on a wire. If the friction force is negligible and the bead has a speed of 100 cm/s at A, what will be its speed at points B and C? [6]

$3(9x+8) - x($

$27x + 24$

$\frac{27}{27}x = \frac{24}{27}$

$x = 0.8$

0.87

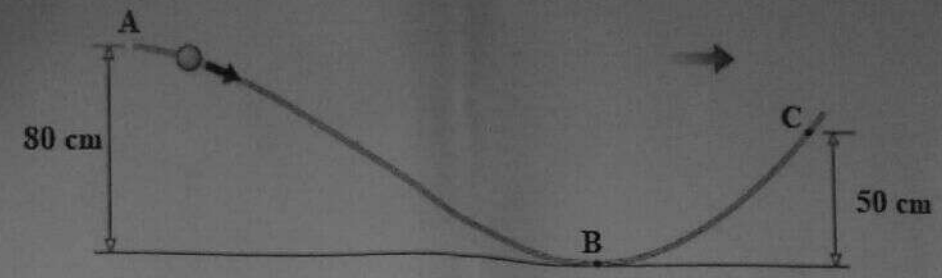


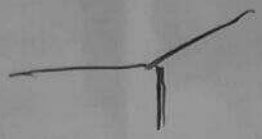
Figure 4.1

(c) At a four-way road intersection, a truck of mass 7.2×10^3 kg travelling east at the speed of 15 m/s collides head-on with a car of mass 2.5×10^3 kg travelling north at the speed of 20 m/s. The two vehicles become entangled in a perfectly *inelastic collision* and slide as one body.

(i) State the impulse-momentum theorem. **[1]**

(ii) What is meant by the term *inelastic collision*? **[1]**

(iii) Calculate the speed and direction of the wreckage immediately after collision? **[8]**



QUESTION FIVE

(a) A solid cylinder of mass 20 kg rotates about its axis with angular speed 100 rad/s and its **moment of inertia (I)** is 0.625 kg.m^2.

(i) Define the **moment of inertia** of a particle about a given axis. **[1]**

(ii) Calculate its rotational kinetic energy and radius of gyration. **[3]**

(b) A solid sphere of mass M and radius R rolls down an incline of height H from rest without slipping (see Figure 5.1). Show that its speed when it reaches the bottom of the incline is $v = \sqrt{\frac{10}{7}gH}$ where g, is the acceleration due to gravity and $I_{sphere} = \frac{2}{5}MR^2$. **[6]**

$\frac{1}{\varphi}ML^2 + \frac{1}{12}Mv^2$

$2gh = \frac{2}{m}\frac{v^2}{R^2}$

$\left(2gh = \frac{2}{5}v^2 + v^2\right)5$

$10gh = 2v^2 + 10v^2$

A - B

$ME = M \cdot E$

$KE + mgh = KE + mgh$

$\left(\frac{1}{2}mv^2 + mgh = \frac{1}{2}Iv^2 + 0\right)\frac{2}{m}$

$\frac{1}{2}KE + mgh = KE + mgh$

$v_i^2 + gh = v_f^2$

$(0.1)^2 + 9.8 \times 0.8 = v^2$

$0.01 + 7.84$

6

$\sqrt{v^2} = \sqrt{7.85}$

$v = 2.8$

$v = r\omega$

$\omega = \frac{v}{r}$

16.2^2

$\frac{v}{r}$

1

$\frac{2}{3}$

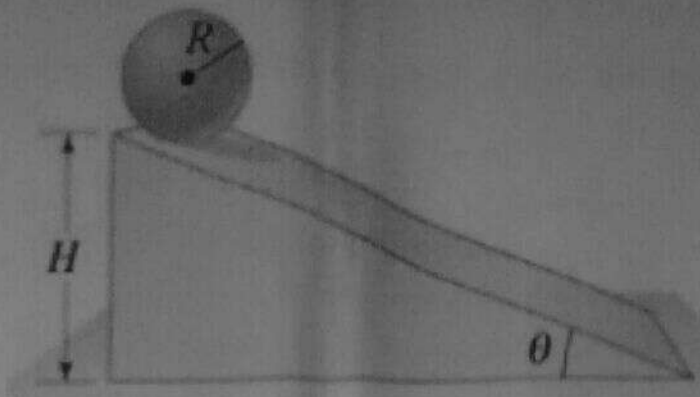


Figure 5.1

c) The displacement x *in* meters of a body moving with simple harmonic motion (SHM) is given by the equation $x = 3.5\sin(4t + 0.2)$.

(i) What is the amplitude of the motion? **[1]**

(ii) what is the value of the constant ω? **[1]**

(iii) Determine the frequency of the motion. **[2]**

(iv) Calculate the period of the motion. **[2]**

(v) What will be the displacement o.2 seconds after the measurement begun? **[2]**

(vi) Calculate the velocity of the motion at 1.5 seconds. **[2]**

QUESTION SIX

a) Two metal spheres on insulated stands carry charges of +4 μC and -6 μC respectively. The spheres are arranged with their centres 40 cm apart, as shown in Figure 6.1.

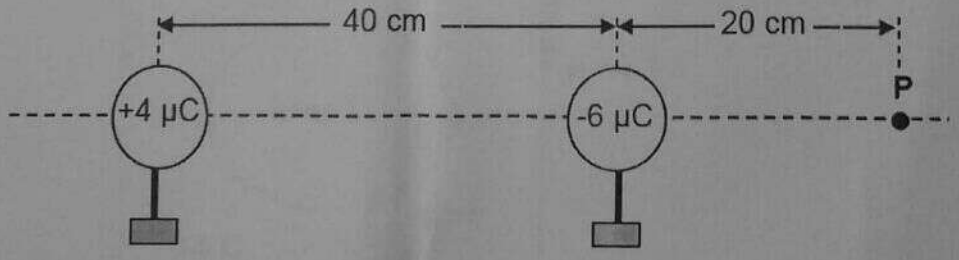


Figure 6.1

(i) Calculate the magnitude of the force exerted by each sphere on the other. **[2]**

(ii) Calculate the net electric field at point P as shown in the diagram above. [3]

b) Consider the electric circuit in Figure 6.1 and answer the questions that follow.

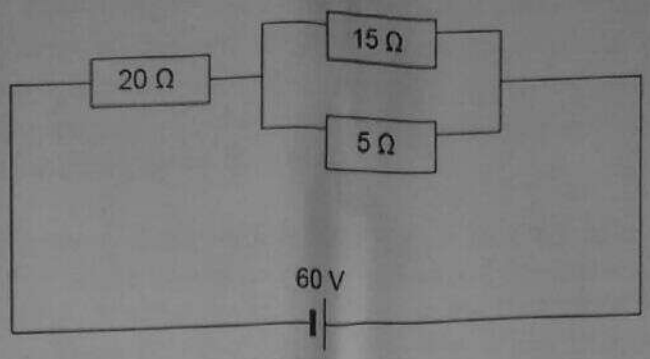


Figure 6.2

(i) Calculate the magnitude of the current flowing through the whole circuit. [3]

(ii) Calculate the potential difference across the 15 Ω resistor. [2]

c) (1) State Kirchoff's laws for electrical circuits. [4]

(2) For the given circuit in Figure 6.3, use the given nodes and loops to apply Kirchoff's Laws to find:

(i) the currents I_2 and I_3 ; [4]

(ii) the value of R. [2]

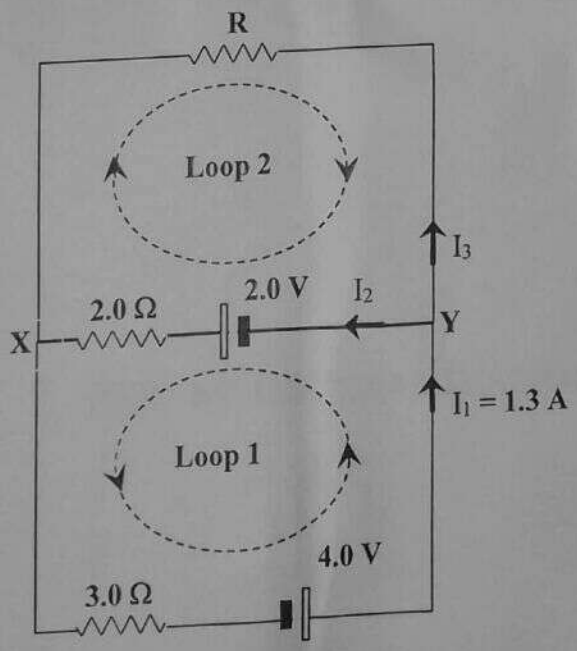


Figure 6.3

QUESTION SEVEN

(a)

(i) Assuming that the electron in a hydrogen atom orbits the proton in a circular motion at a fixed radial distance of 5.30×10^{-11} m and given that this orbiting electron experiences a net force of magnitude 8.20×10^{-8} N; calculate the period of orbit of the electron, giving your answer to three significant figures and in SI Units. **[5]**

(ii) A car accelerates uniformly from 15 m/s to a speed of 55 m/s in a time interval of 8 s while travelling in a clockwise direction on a circular track of radius 400 m. Calculate the minimum coefficient of static friction that is needed between the car's tyres and the track to sustain this motion. **[5]**

(b)

(i) State Newton's law of universal gravitation. **[2]**

(ii) State Kepler's three laws of planetary motion. **[3]**

(iii) Given that the mass of Jupiter is 1.90×10^{27} kg and that of the Sun is 1.99×10^{30} kg and that the mean distance between the Sun and Jupiter is 7.80×10^{11}. Assuming the orbit of Jupiter around the Sun to be circular, giving your answer to three significant figures, calculate the gravitational force, which Jupiter exerts on the Sun. **[5]**

[END OF THE EXAMINATION]

The Copperbelt University (CBU)

School of Mathematics and Natural Sciences

PH 110 Test 1 – Deferred **September 2020** **Online**

Name: _____ Id Number:_____

Group: _____

Use gravitational acceleration g = 9.82 m/s^2 where not specified.

ANSWER ALL QUESTIONS

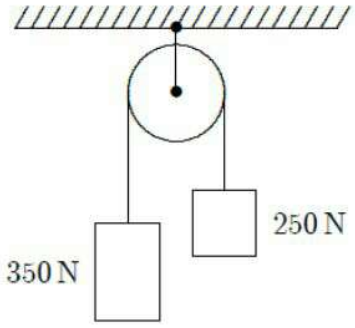
1. In a freefall vertical motion where the time of ascent is equal to the time of descent, use equations to show that the initial velocity at firing upwards is equal to the final velocity at landing. [10 marks]

2. Explain why your weight may be different when you are in Kitwe compared to when you are in Gwembe valley even when your mass is the same. [10 marks]

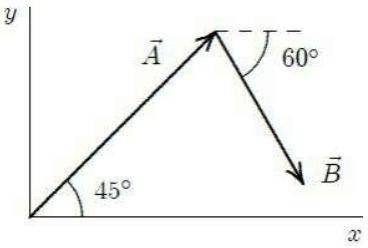
3. Explain with the use of equations why a pistol fired from the clouds 10 km away is capable of killing a person on the ground compared to when it is fired horizontally over same distance. [10 marks]

4. A 1000 kg elevator is rising and its speed is increasing at 8 m/s^2. Calculate the tension of the cable holding the elevator [10]

5. Two blocks, weighing 350 N and 250 N, respectively, are connected by a string that passes over a massless pulley as shown. Calculate the tension in the string and explain why the tension on the left is not greater than the tension on the right side. [10 marks]



6. In the diagram, $\vec{A}$ has magnitude 12 N and $\vec{B}$ has magnitude 8 N. Calculate the x component of $\vec{A} + \vec{B}$ [15 marks]



7. A projectile is fired at an angle of 65 degrees to the horizontal with initial velocity of 100 m/s. Find:

   i. Time of ascent [5 marks]
   ii. Time of flight [5 marks]
   iii. Maximum height reached [5 marks]
   iv. Range [5 marks]
   v. Maximum possible range [5 marks]

8. Find the center of mass of a system of particles in the Cartesian coordinates for Mass (x, y, z) as follows: 10 kg (-2, 4, 2), 5 kg (6, 8, 2), and 15 kg (0, -7, 2). [10 marks]

`````` COVID19 IS REAL `````` STAY SAFE`````` THE END ``````````````````
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THE COPPERBELT UNIVERSITY

PHYSICS DEPARTMENT

TEST 1 – AUGUST 2020

PH 110 – *INTRODUCTORY PHYSICS*

TIME: **2** HOURS MAX MARKS: **100**

ATTEMPT **ALL** QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

CLEARLY INDICATED YOUR STUDENT IDENTIFICATION NUMBER AND LECTURE GROUP ON THE FRONT COVER OF THE ANSWER BOOKLET

You may use the following information:

Acceleration due to gravity, $g = 9.8\ m/s^2$

Q1. (a) A car travels 1 km between two stops. It starts from rest and accelerates at 2.5 m/s^2 until it attains a velocity of 12.5 m/s. The car continues at this velocity for some time and decelerates at 3 m/s^2 until it stops. Calculate the total time for the journey. **[10 marks]**

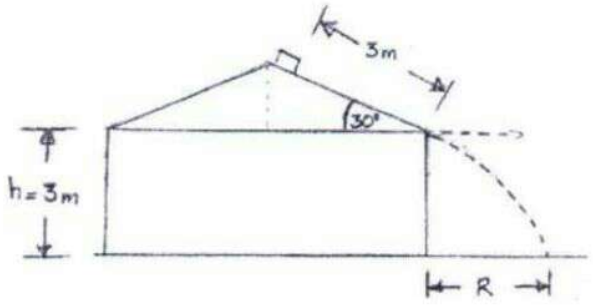
(b) A crate slides from rest and accelerates uniformly at 4.9 m/s^2 along a frictionless roof 3 m long which is inclined at an angle of 30^o to the horizontal as indicated in the Figure below. Determine:

(i) the velocity of the crate just after losing contact with the roof,

(ii) the velocity (magnitude and direction) of the crate just before it hits the ground,

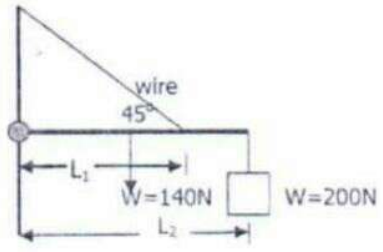
(iii) the time the crate takes to hit the ground after losing contact with the roof, and

(iv) the horizontal distance between the point directly below the roof and the landing Point (i.e. the range). **[15 marks]**



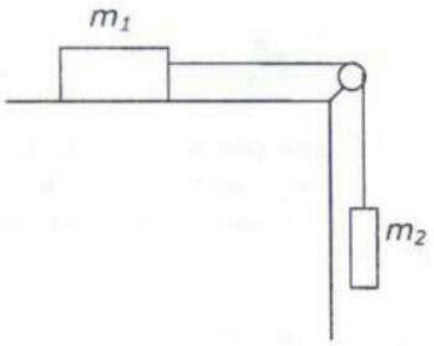
Q2. (a) A block of weight $W = 200$ N is supported by a uniform beam of weight 140 N as shown in the Figure below. If $L_1 = 1.1$ m and $L_2 = 1.4$ m, find the tension in the wire and the vertical and horizontal components of the force exerted by the hinge on the beam.

[10 marks]

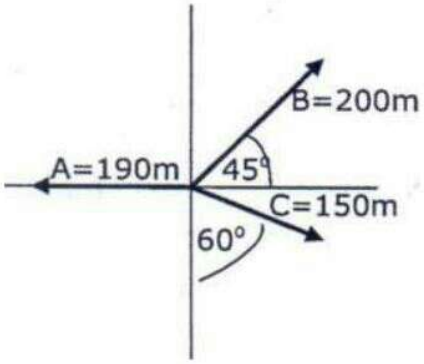


(b) (i) Give two conditions required for an object to be static equilibrium. [**4 marks**]

(ii) Two objects with masses m_1 = 10 kg and m_2 = 5 kg are connected by a light string that passes over a frictionless pulley as shown in the Figure below. If, when the system starts from rest, m_2 falls 1 m in 1.2 seconds, determine the coefficient of kinetic friction between m_1 and the table. [**11 marks**]



Q3. (a) The magnitude and directions of three vectors $\vec{A}$, $\vec{B}$ and $\vec{C}$ are as shown in the Figure below. Find the magnitude and direction of a fourth vector $\vec{D}$ which when added to these three vectors will give a resultant of zero. [**12 marks**]



(b) Two people pull as hard as they can on ropes attached to a 200 kg object. If they pull in the same direction the object accelerates at 1.52 m/s^2 to the right. If they pull in opposite directions the object accelerates at 0.518 m/s^2 to the left. Ignoring any other forces, what is the force exerted by each person on the object? [**9 marks**]

(c) If $\vec{A}$ and $\vec{B}$ are nonzero vectors, is it possible for $\vec{A} \cdot \vec{B}$ and $\vec{A} \times \vec{B}$ both to be zero? Explain.

[4 marks]

Q4. (a) An acre-foot is the volume of water that would cover 1 acre of flat land to a depth of 1 foot. How many gallons are in 1 acre-foot? **[5 marks]**

(b) You are using water to dilute small amounts of chemicals in the laboratory, drop by drop. How many drops of water are in a 1.0-L bottle? **[9 marks]**

(c) (i) State the principle of homogeneity. **[2 marks]**

(ii) The wavelength λ associated with a moving particle depends on its mass m, velocity v and Planck's constant h which is measured in kgm^2s^{-1}. Show dimensionally, that

$$\lambda \propto \frac{h}{mv}$$ **[9 marks]**

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THE COPPERBELT UNIVERSITY

PHYSICS DEPARTMENT

UNIVERSITY EXAMINATIONS– 2019/2020

PH 110 – *INTRODUCTORY PHYSICS*

TIME: **3** HOURS

MAX MARKS: **100**

ATTEMPT ANY **FIVE (5)** QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

CLEARLY INDICATE YOUR STUDENT IDENTIFICATION NUMBER AND LECTURE GROUP ON THE FRONT COVER OF THE ANSWER BOOKLET

You may use the following information:

Acceleration due to gravity, $g = 9.8\ m/s^2$

QUESTION ONE

(a) A car moves 10 km east at 60 km per hour, then 5 km north at 100 km per hour, and finally 10 km south at 70 km per hour. Find the:

(i) Magnitude of the displacement **[2 Marks]**

(ii) Angle of displacement measured counterclockwise **[2 Marks]**

(iii) The distance covered **[2 Marks]**

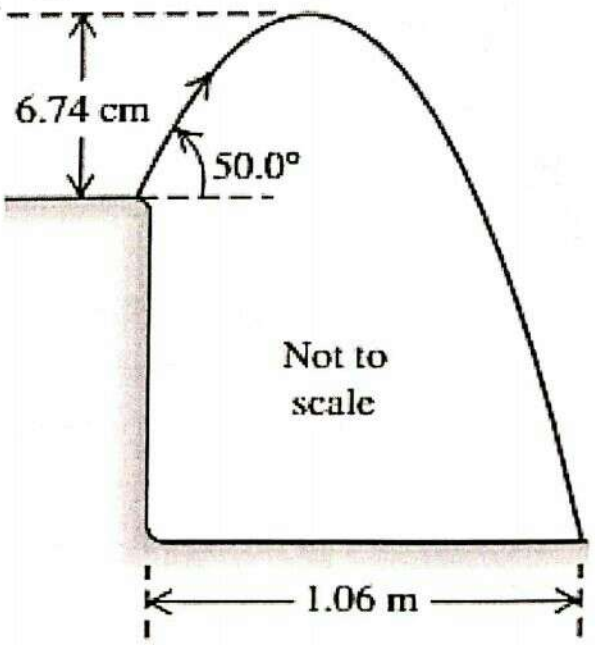
(iv) Average speed **[2 Marks]**

(v) Average velocity **[2 Marks]**

(b) A grasshopper leaps into the air from the edge of a vertical cliff, as shown in the Figure below. Use information from the figure to find

(i) the initial speed of the grasshopper and **[4 Marks]**

(ii) the height of the cliff. **[6 Marks]**



QUESTION TWO

(a) The three finalists in a contest are brought to the centre of a large, flat field. Each is given a metre stick, a compass, a calculator, a shovel and the following three displacements:

72.4 m, 32^0 east of north;

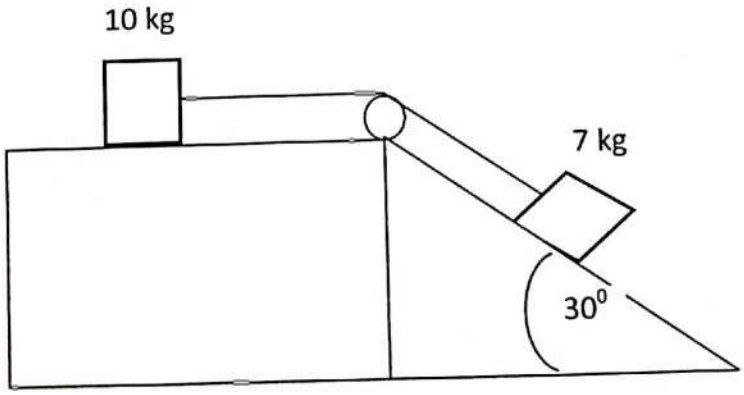
57.3 m, 36^0 south of west;

17.8 m straight south.

The three displacements lead to a point where the keys to a new building are buried. Two contestants start measuring immediately; the winner first calculates where to go. Using the method of components, what does the winner calculate in terms of magnitude and direction?

[10 Marks]

(b) A 10 kg box is attached to a 7 kg box which rests on a 30^0 incline as shown below. The coefficient of kinetic friction between each box and the surface is $\mu_k = 0.1$.



With the aid of a diagram showing forces acting on the boxes, calculate:

(i) the frictional force for the 10 kg box, **[2 Marks]**

(ii) the frictional force for the 7 kg box, **[2 Marks]**

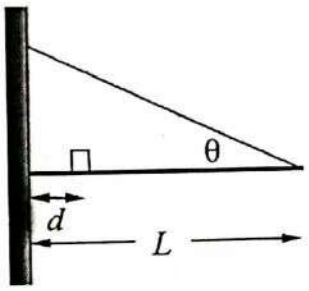
(iii) the acceleration of the system and **[3 Marks]**

(iv) the tension in the rope. **[3 Marks]**

$T - f_k - mg = ma.$

QUESTION THREE

(a) A uniform steel beam of mass $m_1 = 2.0 \times 10^2$ kg is held up by a steel cable that is connected to the beam a distance $L = 5.0$ m from the wall, at an angle $\theta = 30^0$ as shown in the sketch. The beam is bolted to the wall with an unknown force **F** exerted by the wall on the beam. An object of mass $m_2 = 6.0 \times 10^1$ kg, resting on top of the beam, is placed a distance $d = 1.0$ m from the wall.



(i) Draw a free-body diagram for the beam. **[3 Marks]**

(ii) Find equations for static equilibrium for the beam (this will involve force equations and torque relations). **[4 Marks]**

(iii) Find the tension in the cable. **[4 Marks]**

(iv) Find the horizontal and vertical components of the force that the wall exerts on the beam. **[4 Marks]**

(b) An 8.0 g cork is swung in a horizontal circle with a radius of 35 cm. It makes 30 revolutions in 12 seconds. What is the tension in the string? (Assume the string is nearly horizontal) **[5 Marks]**

QUESTION FOUR

a) Show **mathematically** the relationship between linear momentum and Newton's second law of motion. **[4 Marks]**

b) A 1.5 kg ball moving at 8.0 m/s makes an off-centre collision with a 2.5 kg ball that is initially at rest. After the collision, the 1.5 kg ball is deflected at an angle of $\pi/6$ from its original direction of motion and the 2.5 kg ball is moving at 2.0 m/s. Determine the speed of the 1.5 kg and the direction of the 2.5 kg ball after the collision. **[8 Marks]**

c) Two particles with masses 2.0 kg and 6.0 kg are moving towards each other along the x axis with the same initial velocity, V_i. Particle with 2.0 kg is travelling to the right; they undergo an elastic glancing collision such that particle with 2.0 kg is moving downwards after the collision at $\pi/2$ from its initial direction. Calculate the velocities of the two particles and the angle at which the particle with 6.0 kg is scattered. **[8 Marks]**

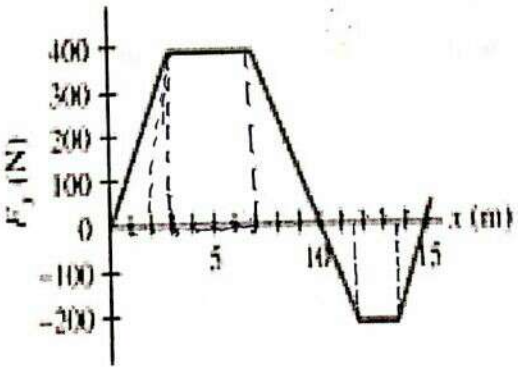
QUESTION FIVE

(a) Work and energy principles have many applications in physics and engineering.

(i) State the work-energy theorem. **[2 Marks]**

(ii) Define gravitational potential energy. **[2 Marks]**

(b) The force on an object, acting along the x-axis, varies as shown in figure below. Determine the total work done by this force to move the object from $x = 0$ m to $x = 15$ m. **[8 Marks]**



(c) A bicyclist rides down on a rough inclined surface at a constant speed of 5.0 m/s. The angle between the incline and the horizontal plane is 10 degrees. Assuming a total mass of 80 kg (Bicycle plus rider).

(i) Draw a free body diagram for the downward movement of the cyclist. **[2 Marks]**

(ii) What must be the cyclist power output to climb the same hill at the same speed? Assume frictional force is the same when the speed is the same. **[6 Marks]**

QUESTION SIX

(a) State two limitations of dimensional analysis. **[4 Marks]**

(b) The square of the speed v of a particle undergoing uniformly accelerated motion depends on the acceleration a and the displacement s. Use dimensional analysis to derive the relationship between v, a and s. **[8 Marks]**

(c) Density is defined as the mass per unit volume. The earth is assumed to be a sphere of radius 6400 km. Estimate the mass of the earth if its density is 5.5 g/cm^3. **[8 Marks]**

QUESTION SEVEN

(a) Define the scalar product of two vectors. **[2 Marks]**

(b) If the magnitudes of two vectors $\vec{A}$ and $\vec{B}$ are 3 and 4 respectively, and their scalar product is 6, find the angle between them and also $|\vec{A} \times \vec{B}|$. **[8 Marks]**

(c) A hotel guest starts to pull an armchair across a horizontal floor by exerting a force of 100 N 15° above the horizontal. The normal force exerted by the floor on the chair is 221 N up. The acceleration of the chair is 0.076 m/s^2. Determine the mass of the chair and the coefficient of kinetic fiction between the chair and the floor. **[10 Marks]**

,,, **END OF EXAMINATION** ,,,

THE COPPERBELT UNIVERSITY

SCHOOL OF MATHEMATICS AND NATURAL SCIENCES

PHYSICS DEPARTMENT

2017/2018 ACADEMIC YEAR

PH 110 TEST 1

INTRODUCTORY PHYSICS

INSTRUCTIONS:

1. THERE ARE FOUR (**4**) QUESTIONS IN THIS PAPER AND EACH QUESTION CARRIES **25** MARKS. ATTEMPT **ALL** QUESTIONS.
2. WRITE YOUR STUDENT IDENTIFICATION NUMBER **(SIN).**
3. INDICATE YOUR GROUP e.g GROUP **A**, GROUP **B**, GROUP **C**, e.t.c

DURATION: TWO (**2**) HOURS

USE THE FOLLOWING DATA WHERE NECESSARY:

Acceleration due to gravity, $g = 9.8\ m/s^2$

$\eta = Kgm^{-1}s^{-1}$

QUESTION 1

a) A dimension is a physical nature of a quantity.

(i) Give two (2) limitations of dimensional analysis. [2 Marks]

(ii) If velocity (**V**), time (T) and force (**F**) were chosen as basic quantities, find the dimensions of mass. [4 Marks]

b) If the units of force, energy and velocity in a new system are 10N, 5J and 0.5 m/s respectively, find the units of mass, length and time in that system. [8 Marks]

c) When a small sphere moves at low speed through a fluid, the viscous force **F** opposing the motion is found experimentally to depend on the radius r, velocity v and the viscosity η of the fluid. Find the force dimension of the force **F**. [5 Marks]

d) A cheap wrist watch loses time at the rate of 8.5s a day. How much time will the watch be off at the end of a month? Given that a month has 30 days. [3 Marks]

e) A solid cube of aluminum (density of 2.7 g/cm^3) has a volume of 0.9 cm^3. How many atoms are contained in the cube? [3 Marks]

$A \cdot B = |A||B|\cos\theta$

$f \propto r v \eta$

$F = r v \eta$ $\quad L L T^{-1}$

$F = ma = kgm/s^2$ $\quad \eta = kg/m \cdot s$ $\quad kgm^2/s^2$

QUESTION 2

(a) Given a vector $\vec{A} = 3\hat{i} + 6\hat{j} - 2\hat{k}$. Find another vector $\vec{B}$ which is parallel to vector $\vec{A}$ and has a magnitude of 17 units. [5 marks]

(b) The following instructions lead to a buried treasure: Go 75 m 30° west of south, turn northwest and walk 125 m, then travel 100 m 20° north of west. Determine the resultant displacement from the starting point. [7 marks]

(c) Which two of the following three vectors are parallel to each other:

$\vec{A} = 3\hat{i} + 6\hat{j} - 2\hat{k}$, $\vec{B} = \hat{i} + 5\hat{j} + 8\hat{k}$, and $\vec{C} = \frac{3}{2}\hat{i} + 3\hat{j} - \hat{k}$. [3 marks]

(d) Find the angles which the vector $\vec{A} = 3\hat{i} - 6\hat{j} + 2\hat{k}$ makes with the coordinate axes. [6 marks]

(e) Determine a vector perpendicular to the plane of $\vec{A} = 2\hat{i} - 6\hat{j} - 3\hat{k}$ and $\vec{B} = 4\hat{i} + 3\hat{j} - \hat{k}$. [4 marks]

QUESTION 3

(a) A stone thrown horizontally from the top of a 24 m tower hits the ground at a point 18 m from the base of the tower.

(i) Find the speed at which the stone was thrown. [4 marks]

(ii) Find the speed of the stone just before it hits the ground. [3 marks]

(b) A marble rolls horizontally off a table with a speed of 3.7 m/s. A second marble is dropped vertically from the table at the same instant. If the table is 1.20 m high,

(i) how far apart do the marbles land? [3 marks]

(ii) what difference is there in the times of impact of the two marbles? [3 marks]

(c) Just as a car starts to accelerate from rest at a constant acceleration of 2.44 m/s^2, a bus moving at a constant speed of 19.6 m/s passes the car in a parallel lane.

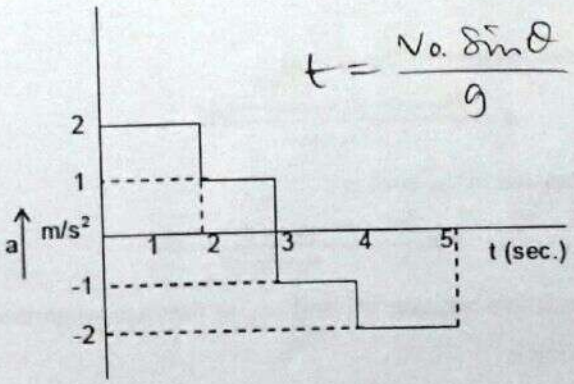
(i) How long does it take the car to overtake the bus? [3 marks]

(ii) How fast is the car going? [2 marks]

(iii) How far has the car gone at that point? [2 marks]

(d) A car starting from rest moving on a straight line has acceleration – time graph as shown in the figure below. Draw the velocity – time graph. [5 marks]

$t = \frac{V_0 \sin\theta}{g}$



QUESTION 4

(a) Explain briefly why

(i) action and reaction (equal and opposite) forces do not cancel each other out, resulting in zero net force. [2 marks]

(ii) a man standing in an elevator going down with uniform acceleration experiences loss of weight [2 marks]

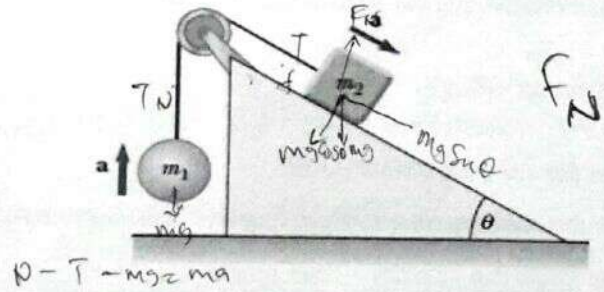
(b) An object of mass 10 g is moving in a plane. Its position as a function of time is given by

$$\vec{r} = (2t^3 - t^2)\vec{i} + (4t^3 + 2t)\vec{j}$$

Find the magnitude and direction of resultant force acting on the object at $t = 2$ s.

[5 marks]

(c) A ball of mass m_1 hanging vertically is connected to a block of mass m_2 lying on the rough inclined surface by means of a light non-stretchable cord over a massless, frictionless pulley as shown in the figure below. The surface is inclined at an angle θ



Show that:

(i) the acceleration of the system is

$$a = \frac{(m_2 \sin\theta - \mu_k m_2 \cos\theta - m_1)g}{m_1 + m_2}$$ [5 marks]

(ii) the tension in the cord is

$$T = \frac{(1 + \sin\theta - \mu_k \cos\theta) m_1 m_2 g}{m_1 + m_2}$$ [3 marks]

(iii) the relation between m_1 and m_2 in the case when the system is on the verge of slipping is

$$m_1 = (\sin\theta - \mu_s \cos\theta) m_2$$ [3 marks]

where μ_s, is the coefficient of static friction, and μ_k is the coefficient of kinetic friction between the block and the surface.

(c) A CBU physics student shopping at Mukuba mall pushes a trolley of mass 18 kg along a rough horizontal surface at a constant speed. To do this requires a force of 80 N directed along the handle, which is at an angle of 40 degrees below the horizontal. Calculate the coefficient of kinetic friction between the wheels of trolley and the surface. [5 marks]

BANDA PAUL
GROUP B

COPPERBELT UNIVERSITY

PHYSICS DEPARTMENT

PH 110 TEST 2 (SEPTEMBER 2019)

TIME ALLOWED: **90** MINUTES MAX MARKS: **50**

ATTEMPT **ALL** QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS

Wherever necessary use:

$$g = 9.8\,m/s^2$$

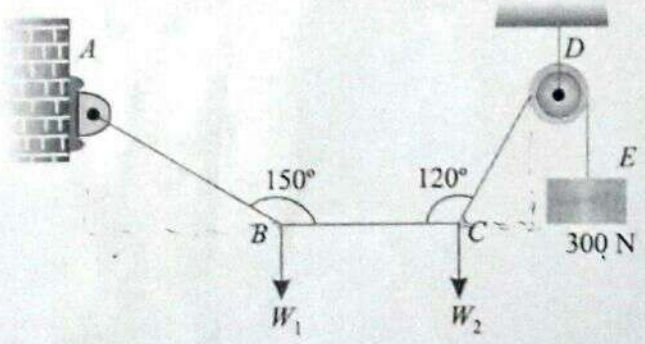
QUESTION ONE

(a) State two conditions necessary for the body to be in static equilibrium. **[3Marks]**

(c) You have a job digging holes for posts to support signs for Fountain Restaurant. Explain why the higher above the ground a sign is mounted, the further the posts should extend into the ground.

[2 Marks]

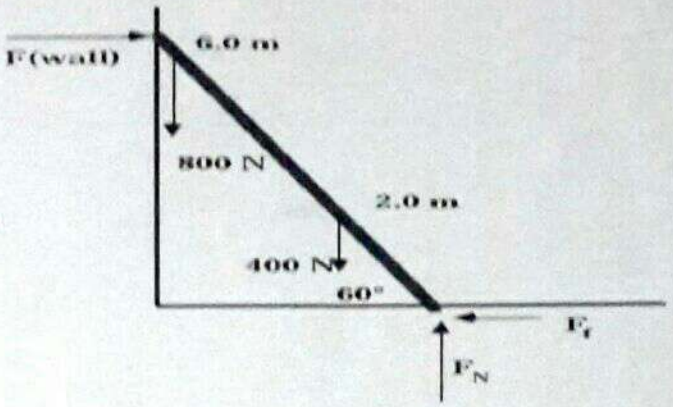
(c) A light string ABCDE whose extremity A is fixed, has weights W_1 and W_2 attached to it at B and C. It passes round a small smooth pulley at D carrying a weight of 300 N at the free end E as shown in the Figure below.



If in the equilibrium position, BC is horizontal and AB and CD make 150° and 120° respectively with BC, Find the tensions in the portion AB, BC and CD of the string, and the magnitudes of W_1 and W_2. **[10 Marks]**

(d) A man who weighs 800 N climbs to the top of a 6 meter ladder that is leaning against a smooth (i.e., **frictionless**) wall at an angle of 60° with the horizontal as sketched in the Figure below. The **non-uniform** ladder weighs 400 N and its center of gravity is 2 meters from the foot of the ladder. What must be the minimum coefficient of static friction between the ground and the foot of the ladder if it is not to slip? **[10 Marks]**

$\tau = rF\cos\theta$



QUESTION TWO

(a) (i) What is an oblique collision? **[2 Marks]**

(ii) State the law of conservation of linear momentum **[2 Marks]**

(iii) Define the coefficient of restitution for a head-on collision between two bodies. **[2 Marks]**

(b) A moving sphere has a head-on elastic collision with an initially stationary sphere. After collision the kinetic energies of the two spheres are equal.

(i) Show that the mass ratio of the two spheres is 0.1716. **[10 Marks]**

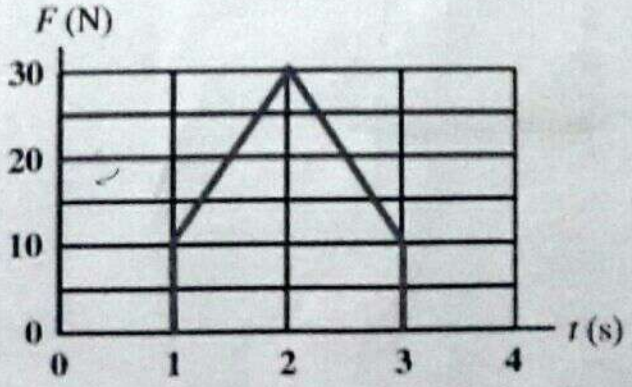
(ii) Which of the two spheres is the more massive? **[2 Marks]**

(c) The force-time graph for a ball struck by a bat is approximated as shown in Figure below. From this graph, find

(i) the impulse delivered by the ball, **[3Marks]**

(ii) the average force exerted on the ball, and **[3Marks]**

(iii) the maximum force exerted on the ball. **[1 Mark]**



&&&&&&&&&&&&&&&&&&&&&&&&**END OF TEST**&&&&&&&&&&&&&&&&&&&&

GLASSY

MAZIT

THE COPPERBELT UNIVERSITY

PHYSICS DEPARTMENT

UNIVERSITY EXAMINATIONS– 2018/2019

PH 110 – *INTRODUCTORY PHYSICS*

TIME: **3** HOURS MAX MARKS: **100**

ATTEMPT ANY **FIVE** QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

CLEARLY INDICATED YOUR STUDENT IDENTIFICATION NUMBER AND LECTURE GROUP ON THE FRONT COVER OF THE ANSWER BOOKLET

You may use the following information:

$$\sin^2\theta + \cos^2\theta = 1$$

Coulomb constant $k = 9\times10^9 \frac{\text{Nm}^2}{\text{C}^2}$

Acceleration due to gravity, $g = 9.8\ \text{m/s}^2$

– GLASSMAN –

Q.1 (a) (i) Distinguish between a fundamental unit and a derived unit. **[3 Marks]**

(ii) Express the speed of light $c = 3.0\times10^8$ m/s in km/h. **[2 Marks]**

(b) A unit of area, often used in measuring land areas, is the *hectare*, defined as 10^4 m^2. A new open-pit copper mine in North-Western Province plans to excavate 75 hectares of land, down to a depth of 26 m in a year. What volume of earth, in cubic kilometers, would be removed during this time? **[5 Marks]**

(c) Dimensional analysis is an important concept in physics. It is the use of fundamental units to establish the form of an equation or more often to check that the answer to a calculation is physically sensible. State the principle of homogeneity and give two limitations of dimension analysis. **[3 Marks]**

(d) The period T of a simple pendulum may depend on mass of m of the bob, length l of the string and the acceleration due to gravity g. Use dimensional analysis to show that the period of the simple pendulum is given by

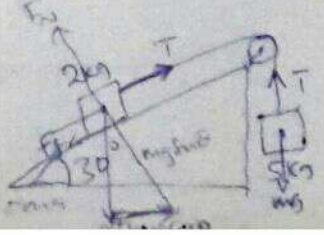
$$T = k\sqrt{\frac{l}{g}}$$

where k, is a dimensionless constant. **[7 Marks]**

Q.2 (a) Define inertia and state Newton's second law of motion. **[2 + 2 Marks]**

(b) A Zambian presidential jet requires for takeoff a speed of 80 km/h, the run on the ground being 100 m. The mass of the plane is 10^4 kg and the coefficient of friction between the plane and ground is 0.2. Assume that the plane accelerates uniformly during the takeoff. What is the maximum force required by the engine of the plane for takeoff? **[8 Marks]**

(c) Two blocks of mass 2 kg and 5 kg are connected by an ideal (light) string passing over a frictionless and massless pulley. The block of mass 2 kg is free to slide on a surface inclined at angle of 30° with the horizontal whereas the 5 kg block hangs freely. Find the acceleration of the system and the tension in the string. Take the coefficient of friction to be $\mu = 0.30$. **[8 Marks]**



Q.3 (a) Work and energy principles have many applications in physics and engineering.

(i) State the work-energy theorem. **[2 Marks]**

(ii) Define gravitational potential energy. **[2 Marks]**

(b) A force acting in the x direction on an object varies with x as shown in Figure 3.1. Find the work done by the force in the intervals $0\text{ m} \le x \le 7\text{ m}$. **[5 Marks]**

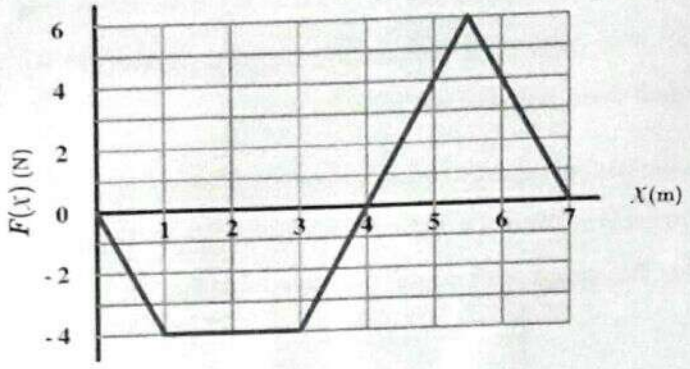


Figure 3.1

(c) A projectile is shot upward from the earth with a speed of 15 m/s. Use the principle of conservation of energy to determine its height when its speed is 8 m/s. Ignore air resistance. **[5 Marks]**

(d) Calculate the minimum power that a motor must have in order to be able to drag a 300 kg box in the positive x-axis along a horizontal floor at a constant speed of 5 m/s if the coefficient of friction is 0.45. **[6 Marks]**

Q.4 (a) A uniform ladder is $L = 6\,m$ long and weighs $400N$. The ladder rests against a slippery vertical wall. The inclination angle between the ladder and the rough floor is $\theta = 53°$. Find the reaction forces from the floor and from the wall on the ladder and the coefficient of static friction μ_s at the interface of the ladder with the floor that presents the ladder from slipping. **[10 Marks]**

(b) If vector $\vec{A} = 3\hat{j}$, $\vec{A}\times\vec{B} = 9\hat{i}$, and $\vec{A}\bullet\vec{B} = 12$, find **[8 Marks]**

(i) Vector $\vec{B}$

$P_i = P_f$

(ii) $\hat{B}$ (i.e., a unit vector in the direction of $\vec{B}$). **[2 Marks]**

Q.5 (a) Two stones are dropped from the edge of a 60 m cliff, the second stone 1.6 s after the first. How far below the top of the cliff is the second stone when the separation between the two stones is 36 m? **[9 Marks]**

(b) A truck travelling east at 18.8 m/s is 1.56 km ahead of a car also travelling east, at 25.5 m/s. Assuming both speeds remain constant, how long will it take for the car to pull even with the truck? **[7 Marks]**

(c) A stone thrown horizontally from the top of a 24 m tower hits the ground at a point 18 m from the base of the tower. (Ignore any effects due to air resistance). Find the speed with which the stone was thrown. **[4 Marks]**

Q.6 (a) (i) State the law of conservation of linear momentum. **[2 Marks]**

(ii) A 2.0 kg ball moving at 10 m/s makes an off-center collision with a 3.0 kg ball that is initially at rest. After the collision, the 2.0 kg ball is deflected at an angle of 30° from its original direction of motion and the 3.0 kg ball is moving at 4 m/s. Find the speed of the 2.0 kg ball and the direction of the 3.0 kg ball after the collision. **[11 Marks]**

$V_f \sin\theta = 20 - 17.3$

$\frac{2.68}{4} = \frac{V_f \sin\theta}{4}$

(b) (i) State the impulse-momentum theorem. **[2 Marks]**

(ii) Figure 5.1 shows an approximate plot of force magnitude F versus time t during the collision of a 58 g superball with a wall. The initial velocity of the ball is 34 m/s perpendicular to the wall; the ball rebounds directly back with approximately the same speed, also perpendicular to the wall. What is F_{max}, the maximum magnitude of the force on the ball from the wall during the collision? **[5 Marks]**

$M_1u_1 + M_2u_2 = M_1v_1 + M_2v_2$

$\theta = -1 \frac{y}{x}$

$V_{1x} = 4\cos\theta$

$\frac{V_x}{V_y}$

$20 = 2v + 12$

$2kg\, v_1 \cos 30 + 3kg$

$2kg\, v_1 \cos\theta + 3kg\, v_2 \cos\theta$

$2 \times 10^2 = 5v^2$

$\frac{200}{5} = \frac{5v}{5}$

$M_1u_1^2 = (m_1 + m_2)v$

$\sqrt{40} = \sqrt{v^2}$

$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$

$v^2 = M_1u_1 = (M_1v_1 + M_2v_2)x$

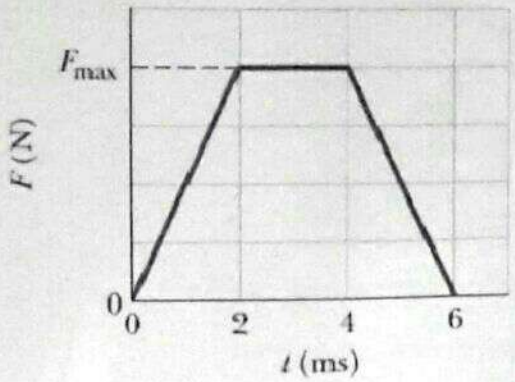


Figure 5.1

Q.7 (a) Find the current in each branch of the circuit shown in Figure 7.1. **[10 Marks]**

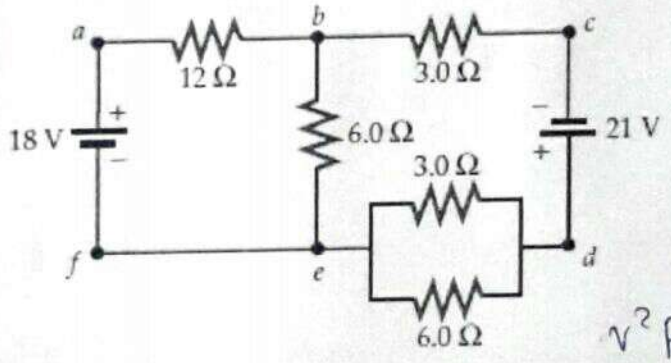


Figure 7.1

(b) Two point particles, each of mass m and charge q are suspended from a common point by threads of length L. Each thread makes an angle θ with the vertical as shown in Figure 7.2.

(i) Show that

$$q = 2L\sin\theta\sqrt{(mg/k)\tan\theta}$$

where k is the Coulomb constant. **[8 Marks]**

(ii) Find q if $m = 10.0$ g, $L = 50$ cm, and $\theta = 10^{\circ}$. **[2 Marks]**

$J = \Delta p$

$F\Delta t =$

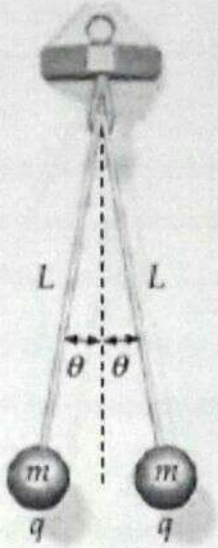


Figure 7.2

.....END OF THE EXAM, GOOD LUCK.....

THE COPPERBELT UNIVERSITY

SCHOOL OF MATHEMATICS AND NATURAL SCIENCES

PHYSICS DEPARTMENT

2017/2018 ACADEMIC YEAR

PH110 TEST 1

INTRODUCTORY PHYSICS

TIME: TWO (2) HOURS

INSTRUCTIONS:

THERE ARE FOUR (4) QUESTIONS IN THIS PAPER. EACH QUESTION CARRIES **25** MARKS. ATTEMPT **ALL** QUESTIONS.

MAXIMUM MARKS: 100

USE THE FOLLOWING DATA WHERE NECESSARY:

Universal gravitational constant, $G = 6.67\times10^{-11}\ \text{Nm}^2\text{kg}^{-2}$
Acceleration due to gravity, $g = 9.8\ \text{m/s}^2$
1 foot = 0.305 m
1 acre = $4.05\times10^3\ \text{m}^2$
1 ft^3 = 7.477 gal
1 mile = 5280 ft

QUESTION ONE

(a) (i) For any equation to be valid, it must be *homogeneous*. Explain what is meant by a *homogeneous* equation. [2 marks]

(ii) The period of a spring executing simple harmonic motion is given by the equation:

$$T = 2\pi\sqrt{\frac{m}{k}}$$

where m is the mass and k is the spring constant given by $k = \frac{Force}{Displacement}$.

Show that the equation is homogeneous. [4 marks]

(b) What are the dimensions of a and b in the relation $F = at + bx$, where F is force, t is the time and x is the distance? [4 marks]

(c) The velocity v of water waves may depend on their wavelength λ, the density of water ρ and the acceleration due to gravity g. Establish dimensionally the relation between these quantities. [7 marks]

(d) If the velocity of light (3×10^8 m/s) is taken as the unit of velocity and a year is taken as the unit of time, what will be the unit of length? [3 marks]

(e) Density is defined as mass per unit volume. A neutron star has a density 2.8×10^{17} kg/m^3. Assume the star to be a perfect sphere. Find the radius of the neutron star whose mass is 4×10^{30} kg. [5 marks]

QUESTION TWO

(a) A particle undergoes three successive displacements in a plane as follows: 4.0 m southwest, 5.0 m east, 6.0 m in a direction 60° north of east. Choose the y–axis pointing north and the x–axis pointing east and find the

(i) magnitude and direction of the resultant displacement, and [7 marks]

(ii) displacement that would be required to bring the particle back to the starting point. [2 marks]

(b) When displacement $\vec{B}$ is added to displacement $\vec{A}$ the result is a displacement $\vec{C}$ that has components $C_x = -3.70\,cm$, $C_y = +2.25\,cm$ and $C_z = +4.60\,cm$. Displacements $\vec{A}$ and $\vec{B}$ are in the same direction, but the magnitude of $\vec{A}$ is only one–third that of $\vec{B}$. Find the components of $\vec{A}$. [4 marks]

(c) In the Figure below $\vec{b}$ and $\vec{c}$ are intersecting face diagonals of a cube of edge a. Find the

(i) components of the vector $\vec{d}$, where $\vec{d} = \vec{b} \times \vec{c}$. [4 marks]

(ii) θ between $\vec{b}$ and $\vec{c}$. [4 marks]

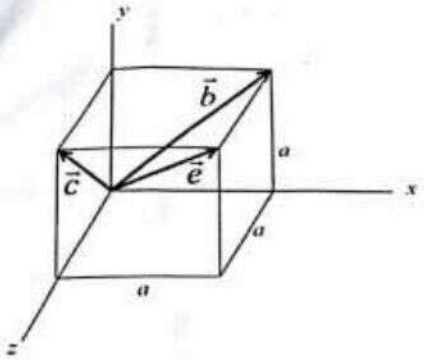
(iii) direction cosines of the body diagonal $\vec{e}$. [4 marks]

$F = at + bx$

$ML T^{-2}$ T^{-2}

$\frac{L}{T^2}$ ac

M^1 $\frac{F}{m}$



Q 2

QUESTION THREE

(a) A ballast bag is dropped from a balloon that is 300 m above the ground and rising at 13 m/s. For the bag, find

(i) the maximum height reached, [2 marks]

(ii) its position and velocity 5 s after it is released, and [2 marks]

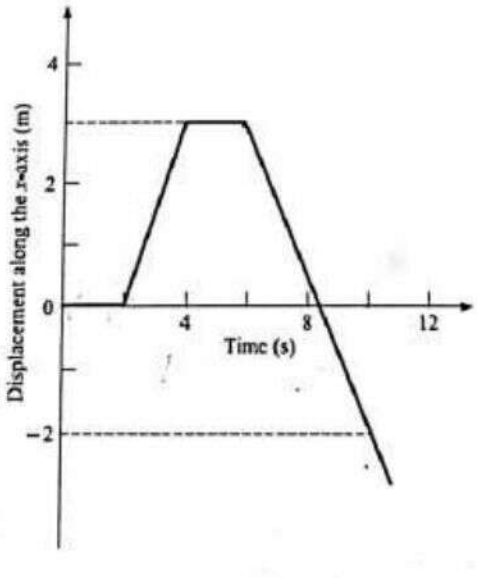
(iii) the time at which it hits the ground. [4 marks]

(b) A ball is thrown from the top of one building towards a very tall building 50 m away. The initial velocity of the ball is 20 m/s, 40° above the horizontal.

(i) At what height, relative to the original level, will the ball strike the opposite wall? [4 marks]

(ii) Is the height in part (i) above or below the original level? Explain. [2 marks]

(c) The graph in the Figure below shows an object's one–dimensional motion along the *x*-axis. Describe its motion. [3 marks]



$x = \frac{1}{2}$

$x = v_0 t + \frac{1}{2} a t^2$

$v_f^2 = v_0'^2 + 2as$

$x = v_a t$

$v_f = \frac{v_0^2 \sin^2 \theta}{2g}$

$h = \left(\frac{-v_f^2 + v_i^2}{2g}\right) + f$

$0 = 13^2 + 2(9.8)$

$y = v_0 t + \frac{1}{2} a t^2$

$v_f = v_0' + at$

(d) A motorcycle policeman hidden at an intersection observes a car that ignores a stop sign, crosses the intersection, and continues on at constant speed. The policeman starts off in pursuit 2.0 s after the car has

$kg \frac{L}{T^2}$ $m \frac{L}{T^2}$

passed the stop sign, accelerates at 6.2 m/s^2 until his speed is 110 km/h, and then continues at this speed until he catches the car. At that instant, the car is 1.4 km from the intersection. How fast was the car traveling? [8 marks]

QUESTION FOUR

(a) Action and reaction forces are equal and opposite, yet they do not cancel each other resulting in zero net force. Why? [2 marks]

(b) A mini bus is moving at the speed of 72 km/h on a horizontal straight rough road. Just before reaching the CBU station, the engine suddenly switches off and the bus skids to a stop through a distance of 50 m. Calculate the coefficient of kinetic friction between the road and the bus's tyres. [5 marks]

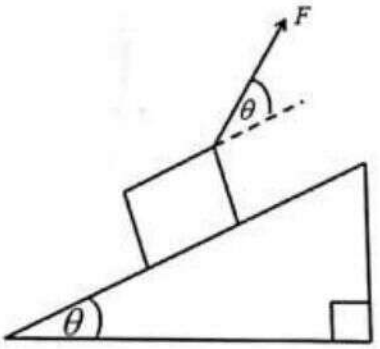
(c) An object of mass 10 g is moving along the x-axis. Its position as a function of time is given by

$$x = (4t^3 + 2t)\, m$$

Find the magnitude of the force acting on the object at $t = 2$ s. [4 marks]

(d) A man gardening pushes a lawnmower at a constant speed. To do this requires a force of 80 N directed along the handle, which is at an angle of 30^0 below the horizontal. The coefficient of kinetic friction between the lawnmower and the surface is 0.25. Find the mass of the lawnmower. [5marks]

(e) A block of mass m on a rough inclined surface is acted upon by a force F at an angle θ with the incline as shown below. The surface is inclined at an angle θ and the coefficient of kinetic friction between the block and the surface is μ_k

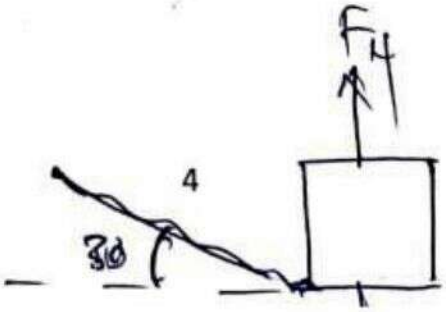


(i) Draw the free body diagram of the block. [2 marks]

(ii) Show that the acceleration of the block is

$$a = \frac{F(\cos\theta + \mu_k \sin\theta) - mg(\sin\theta + \mu_k \cos\theta)}{m}$$ [7 marks]

********** *Good Luck* **********



THE COPPERBELT UNIVERSITY

SCHOOL OF MATHEMATICS AND NATURAL SCIENCES

PHYSICS DEPARTMENT

08/06/2018 ACADEMIC YEAR

PH110 TEST 2

INTRODUCTORY PHYSICS

TIME: TWO (2) HOURS

INSTRUCTIONS:

THERE ARE FOUR (4) QUESTIONS IN THIS PAPER. EACH QUESTION CARRIES **25** MARKS. ATTEMPT **ALL** QUESTIONS.

MAXIMUM MARKS: 100

USE THE FOLLOWING DATA WHERE NECESSARY:

Acceleration due to gravity, $g = 9.8\ m/s^2$

QUESTION ONE

(a) State the law of conservation of linear momentum [3 marks]

(b) An estimated force-time graph for a hockey puck struck by a bat is shown in the Figure 1.1 below. From this graph, find the impulse delivered to the puck and the average force exerted on the puck. [5 marks]

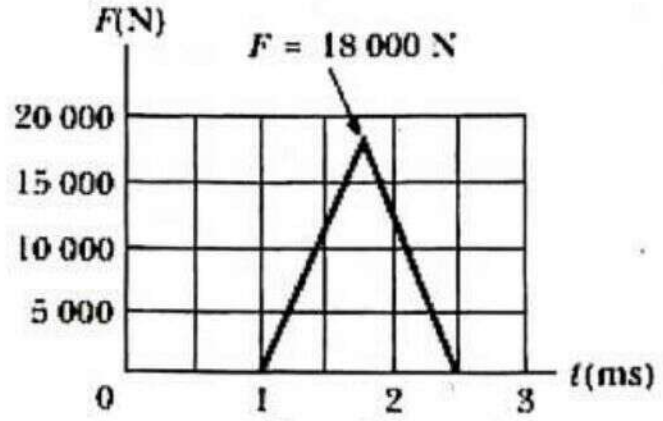


Figure 1.1

(c) A neutron having a mass of $1.67 \times 10^{-27} kg$ and moving at $10^8\ m/s$ collides with a deuteron of mass $3.34 \times 10^{-27} kg$, which is at rest and sticks to it.

(i) What type of collision is in between them? [1 marks]

(ii) What is the speed of the combination immediately after collision? [4 marks]

(iii) How much kinetic energy is lost during collision? [4 marks]

(d) A billiard ball of mass m_1 = 0.4 kg moving with a speed of 3 m/s to the right collides elastically with another ball of mass m_2 = 0.6 kg initially at rest. Find the speed of each ball after the collision. [8 marks]

QUESTION TWO

(a) A civil engineer tasked to construct an overhead bridge ensures that the bridge is in static equilibrium. State two conditions necessary for the bridge to be in static equilibrium. [2 marks]

(b) A box of mass 70 kg is suspended from a horizontally oriented ceiling by two tensions T_1 and T_2 developed in the cables of negligible mass. The tensions T_1 and T_2 make angles of 40° and 30°

receptively to the ceiling as shown in Figure 2.1. The system is in static equilibrium. Determine the tensions T_1 and T_2. [6 marks]

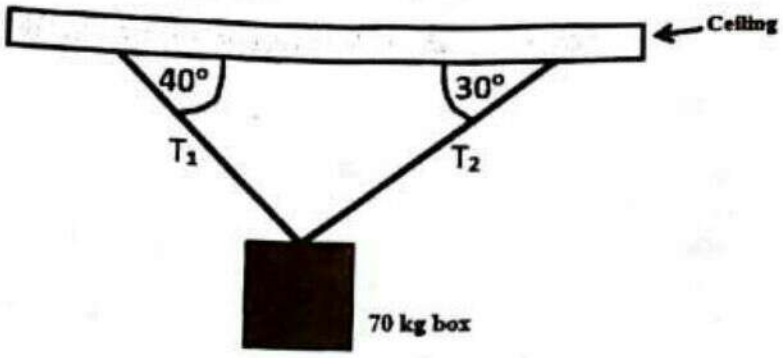


Figure 2.1

(c) The arrangement shown in Figure 2.2 below is in static equilibrium. A uniform beam of length 3 m and mass 50 kg is perpendicularly hinged to a vertically oriented wall at one end and suspended from the wall by a cable that is attached to the other end of the beam at an angle of 40°. A 150 kg box hangs from one end of the beam by a different cable. The hinge forms the rotational axis. Assume the cables have negligible masses and are inextensible. Calculate

(i) the tension T in the cable supporting the beam and [3 marks]

(ii) the component of the force due to the hinge in the x direction (F_{HX}) and the component of the force due to the hinge in the y direction (F_{HY}) that the hinge exerts on the beam. [4 marks]

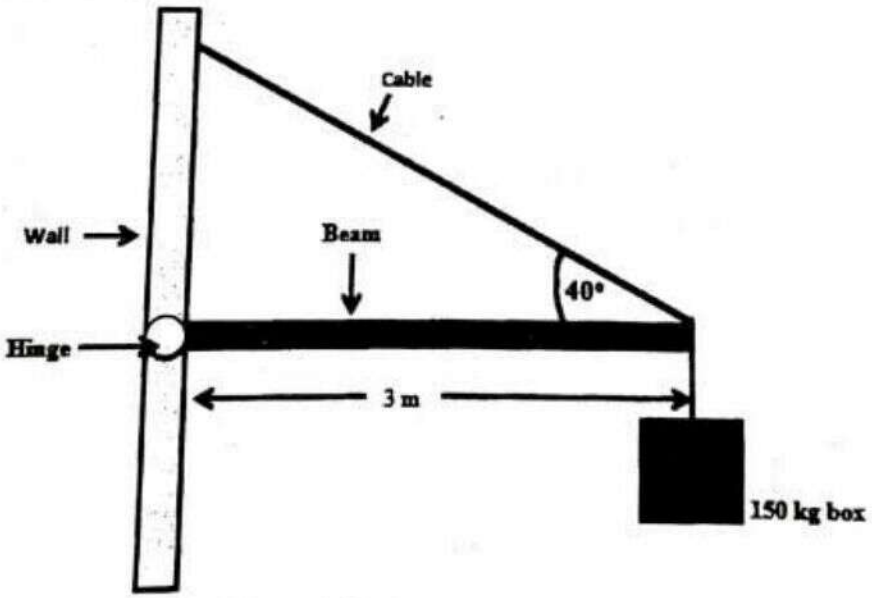


Figure 2.2

(d) A uniform ladder, of length 10 m and mass 22 kg, leans against a smooth wall while its bottom rests on rough ground 2.8 m from the wall. The ladder begins to slip when a 70 kg person climbs 90 percent of the way to the top of the ladder.

(i) Draw the free body diagram. [2 marks]

(ii) What is the coefficient of static friction between the ground and the ladder? [10 marks]

QUESTION THREE

(a) Express (i) 40 deg/s into rev/min [2 marks]

(ii) 1500 rpm into rad/s [2 marks]

(b) Consider a conical pendulum with an 80 kg bob on a 10 m wire making an angle of 5° with the vertical as shown in the Figure 3.1 below. Determine

(i) the horizontal and vertical components of the force exerted by the wire on the bob. [3 marks]

(ii) the radial acceleration of the bob. [2 marks]

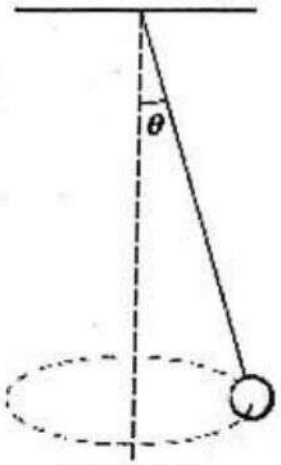


Figure 3.1

(c) A crate of eggs is located in the middle of the flat bed of a pickup truck as the truck negotiates an unbanked curve in the road. The curve may be regarded as an arc of a circle of radius 35 m. If the coefficient of static friction between crate and truck is 0.6, how fast can the truck be moving without the crate sliding?

(d) A stone weighing 2 kg is whirled in a vertical circle at the end of a rope of length 1000 mm. Find the tension in the string and velocity of the stone at

(i) the lowest position,

(ii) midway when the string is horizontal and

(iii) the topmost position to just complete the circle. [4, 4, 4 marks]

QUESTION FOUR

(a) Define work, kinetic energy, and potential energy. [2, 2, 2 marks]

(b) An object of mass m slides down a hill of height h and length l. Show that when the object reaches the bottom of the hill its speed is

$$v = \sqrt{2gh - \frac{2fl}{m}}$$

where f is the average force retarding the motion. [5 marks]

(c) How much work is done by the force $\vec{F} = (-4.0\hat{i} - 6.0\hat{j})\,\text{N}$ on a particle that moves through displacement $\Delta\vec{r} = (-3.0\hat{i} + 2.0\hat{j})\,\text{m}$? [3 marks]

(d) A rectangular block of mass 15 g rests on a rough plane which is inclined to the horizontal at an angle of $\sin^{-1}(0.0525)$. A force of 0.05 N, acting in a direction parallel to the line of greatest slope, is applied to the block so that the block moves up the plane.

When the block has moved a distance of 1.5 m from its initial position, the applied force is removed. The block moves on and comes to rest after travelling a further 0.25 m.

Calculate

(i) the work done by the applied force [3 marks]

(ii) the potential energy gain of the block [3 marks]

(iii) the value of the coefficient of sliding friction between block and the surface of the inclined plane [5 marks]

@@@@@@@@@@@@@@@@@ GOOD LUCK @@@@@@@@@@@@@@@@@

THE COPPERBELT UNIVERSITY

SCHOOL OF MATHEMATICS AND NATURAL SCIENCES

PHYSICS DEPARTMENT

2017/2018 ACADEMIC YEAR

SESSIONAL EXAMINATIONS

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PH 110: INTRODUCTORY PHYSICS - I

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER ANY FIVE (5) QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS. THE MARKS ARE SHOWN IN BRACKETS. CLEARLY INDICATE THE QUESTIONS YOU HAVE ATTEMPTED ON THE COVER PAGE OF YOUR ANSWER BOOKLET.

MAXIMUM MARKS: **100**

DO NOT FORGET TO WRITE YOUR STUDENT IDENTIFICATION NUMBER (S.I.N) ON THE ANSWER BOOKLET!

USE THE FOLLOWING DATA WHERE NECESSARY:

Acceleration due to gravity, $g = 9.8\ m/s^2$
Universal gravitational constant, $G = 6.67\times10^{-11}\ Nm^2Kg^{-2}$
Mass of electron, $m_e = 9.11\times10^{-31}$ kg; Mass of proton, $m_p = 1.67\times10^{-27}$ kg
$k = 9.0\times10^9\ Nm^2C^{-2}$

$$I_{sphere} = \frac{2}{5}mr^2$$

QUESTION ONE

(a) Dimensional analysis plays a vital role in the quantitative analysis of physical quantities.

(i) What is a physical quantity? [1 mark]

(ii) State two applications of dimensional analysis? [2 marks]

(iii) State any two limitations of dimensional analysis? [2 marks]

(b) A physics student conducting a laboratory experiment on kinematics derives a formula for velocity (v) of an object that varies with time expressed as $v = At^2 + Bt + C$, where velocity (v) and time (t) are expressed in terms of SI units. Determine the units of constants A, B, and C in the given equation. [3 marks]

(c) The centripetal force F acting on a particle moving uniformly in a circle depends on the mass of the particle m, the velocity of the particle v, and radius of the circle r. Use dimensional analysis to derive the formula for centripetal force. [3 marks]

(d) Find the angle θ, where θ is $0° < \theta < 180°$ between two force vectors of equal magnitude F, such that the resultant vector R is one-third of each of the original forces. [3 marks]

(e) The resultant displacement, $\bar{D}$, of three successive displacements is 100 m from the origin at an angle of 37° above the positive x-axis. If $\vec{d}_1$ is 100 m along the negative x-axis and $\vec{d}_2$ is 200 m at an angle of 150°, determine the magnitude and direction of the third vector $\vec{d}_3$. [6 marks]

QUESTION TWO

(a) An object moving along the x-axis in such a way that its displacement x is given by the expression

$$x = 30 + 20t - 15t^2$$

where x is in meters (m) and t is in seconds (s).

(i) Find the expressions for the velocity v and acceleration a. [2 marks]

(ii) Find the value of the initial position and the initial velocity of the object. [1 mark]

(iii) At what time and distance from the origin is the velocity zero? [2 marks]

(b) A motorcycle policeman hidden at an intersection observes a car that ignores a stop sign, crosses the intersection, and continues on at constant speed. The policeman starts off in pursuit 2.0 s after the car has passed the stop sign, accelerates at 6.2 m/s^2 until his speed is 110 km/h, and then continues at this speed until he catches the car. At that instant, the car is 1.4 km from the intersection. How fast was the car travelling? [5 marks]

(c) A projectile is shot from the edge of the building top 125 m above the ground level with an initial speed of 65 m/s at an angle of 37° with the horizontal as shown in Figure 2.1.

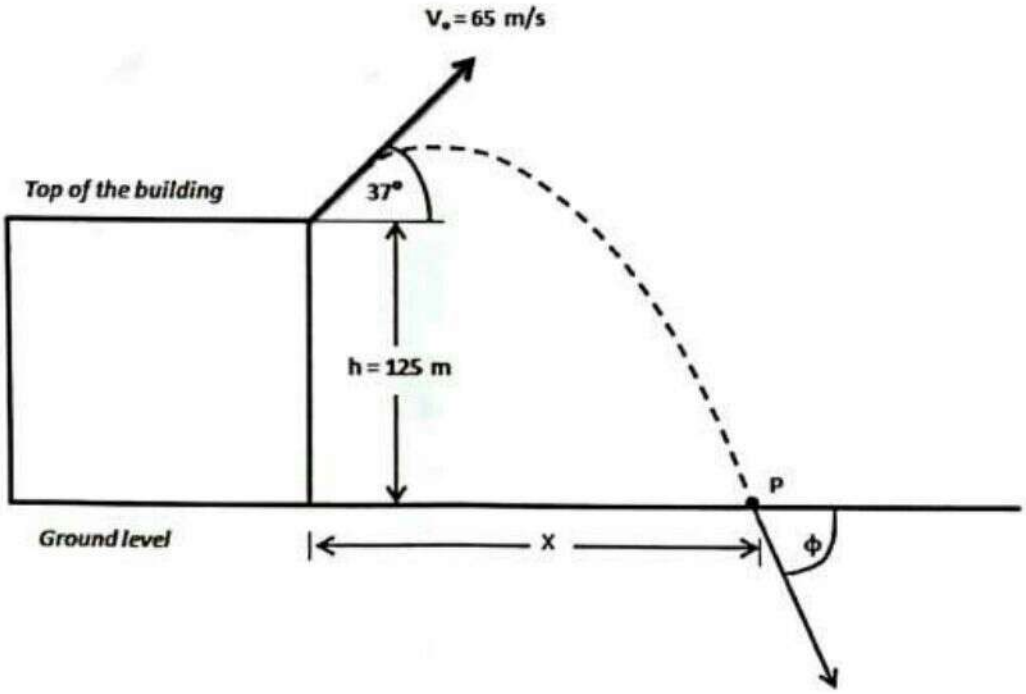


Figure 2.1

Determine

(i) The time taken by the projectile to hit point P at ground level. [2 marks]

(ii) Determine the range x of the projectile measured from the base of the building as shown in Figure 2.1. [2 marks]

(iii) The magnitude of velocity just before the particle reaches the ground. [2 marks]

(iv) The angle ϕ below the horizontal made by the velocity vector. [2 marks]

(v) The maximum height reached by the projectile from the top of the building. [2 marks]

QUESTION THREE

(a) Briefly (in one sentence) explain why

(i) passengers are thrown forward from their seats when a speeding bus stops suddenly. **[1 mark]**

(ii) action and reaction forces do not cancel each other yet they are equal and opposite. **[1 mark]**

(b) A car is moving along a straight level road at a speed of v m/s. Assume that the engine is switched off and the car skids to a stop. Show that the car's stopping distance is

$$s = \frac{v^2}{2g\mu_k}$$

where μ_k is the coefficient of kinetic friction between the tyres and the road, and g is the acceleration due to gravity. **[4 marks]**

(c) Two masses of 5 kg and 3 kg are suspended with help of a massless inextensible string as shown Figure 3.1. Calculate the tensions T_1 and T_2 when the system is going upwards with acceleration $a = 2$ m/s^2. **[4 marks]**

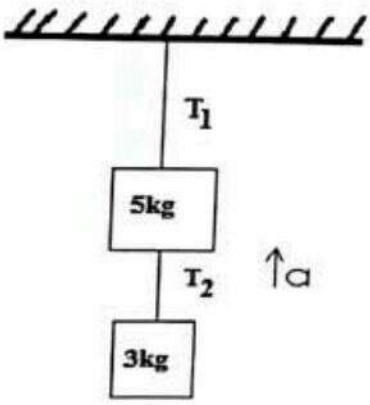


Figure 3.1

(d) A ballet dancer spins about a vertical axis at 1 rev/min with her arms stretched. With arms folded her moment of inertia about the vertical axis decreases to 40% of the initial value. Calculate her new rate of revolution. **[3 marks]**

(e) A solid sphere of mass m and radius r initially at rest rolls down an inclined plane from a height h. The sphere rolls smoothly and friction energy losses are negligible. Derive an expression for the speed of the sphere at the foot of the plane and show that it is independent of the mass of the sphere. Hence or otherwise calculate the value of this

speed given that the length of the plane is 3 m and that angle at which the plane is inclined is 37°. [7 marks]

QUESTION FOUR

(a) (i) What is an inclined plane? [2 marks]

(ii) Give three examples of inclined plane, commonly used in daily life. [3 marks]

(b) A lever of class-I has a total length of 4m and is able to lift a load of 40 kg with a force of 40N. Find the position of the fulcrum. [5 marks]

(c) What two conditions must be satisfied for a body to be in static equilibrium? [2 marks]

(d) A person of mass m_p is standing on a rung one third of the way up a uniform ladder of mass m_L and length d. The ladder is inclined at an angle θ with respect to the horizontal. Assume there is no friction between the ladder and the wall but there is friction between the base of the ladder and the floor with a coefficient of static friction μ_s. Find the minimum coefficient of friction between the ladder and the floor so that the person and ladder do not slip? [8 marks]

QUESTION FIVE

(a) Consider a constant impulsive force F which acts for a time t on a body of mass m, thus changing its velocity v_i to v_f. Let the body travel in a straight line with constant acceleration a. Define impulse and show that the impulse of a force is equal to the change in momentum of the body which it produces. [4 marks]

(b) A stationary piece of wood of mass $M = 5$ kg is suspended by threads. A gun is fired in the horizontal direction and the bullet penetrates inside and consequently the piece is raised to a maximum height $h = 15$ cm. This arrangement is called ballistic pendulum, see Figure 5.1. If the mass m of the bullet is 20 g, find the initial velocity v of the bullet. [5 marks]

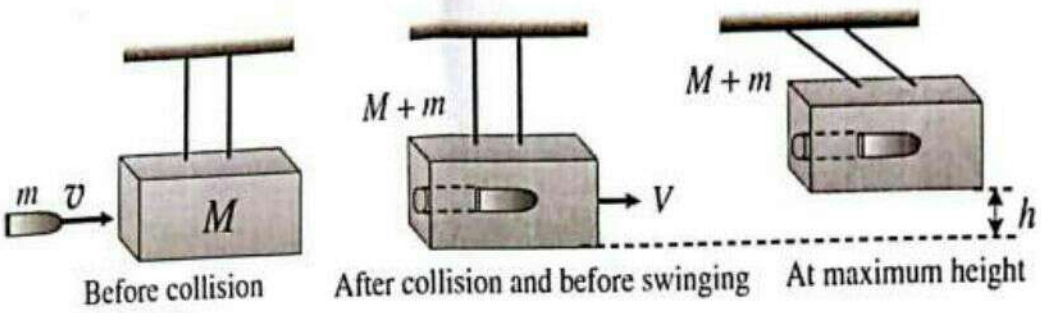


Figure 5.1

(c) A particle moving along the x-axis is subjected to a force given by

$$F(x) = \left(2 + \frac{1}{2}x\right)\text{N}.$$

Find the work done by the force in moving the particle from the origin to a new position $x = 8$ m. **[4 marks]**

(d) A hotel guest starts to pull an arm chair of mass 25 kg initially at rest by exerting a constant force of 90 N at an angle of 15° above the horizontal. The coefficient of kinetic friction between the chair and the floor is 0.2.

(i) Use work-energy theorem to find the speed of the chair after it moves a distance of 5 m horizontally. **[6 marks]**

(ii) What power is delivered by the guest to the chair after it moves a distance of 5 m horizontally? **[1 mark]**

QUESTION SIX

(a) (i) State Newton's law of universal gravitation. **[2 marks]**

(ii) If the mass of the Sun is 2×10^{30} kg, the distance of the Earth from the Sun is 1.5×10^{11} m and the period of revolution of the former around the latter is 365.3 days, show that the universal gravitational constant

$$G = 6.688\times10^{-11}\ \frac{\text{Nm}^2}{\text{kg}^2}.$$

[8 marks]

(b) A satellite revolves in a circular orbit at a height of 200 km from the surface of the Earth. If the period of revolution of the satellite is 90 minutes and the mean radius of the Earth is 6×10^6 m, calculate the average density of the Earth. [8 marks]

(c) A coin is placed on a turntable that is rotating at 33.3 rpm. If the coefficient of static friction between the coin and the turntable is 0.1, how far from the center of the turntable can the coin be placed without having it slip off? [4 marks]

(d) Your car's wheels are 65 cm in diameter and the wheels are spinning at an angular velocity of 101 rad/s. How fast is your car moving in kilometers per hour assuming that there is no slippage? [3 marks]

QUESTION SEVEN

(a) (i) State Coulomb's law. [1 mark]

(ii) The charges in Figure 7.1 are located at the vertices of an equilateral triangle of side 50 cm. If $q_1 = +5.0\,\mu C$, , $q_2 = +6.0\,\mu C$, and $q_3 = -4.0\,\mu C$, find the magnitude and direction of the electrostatic force on q_2. [7 marks]

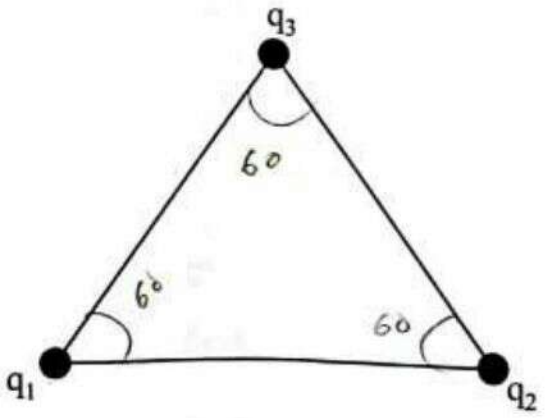


Figure 7.1

(b) State Kirchhoff's current and voltage rules. [2 marks]

(c) For the circuit given in Figure 7.2 find the

(i) currents in each part of the circuit, and [7 marks]

(ii) voltage drop across the 9 Ω, 20 Ω, and 12 Ω resistors. [3 marks]

$v = v + at$ $\omega t - \omega v$

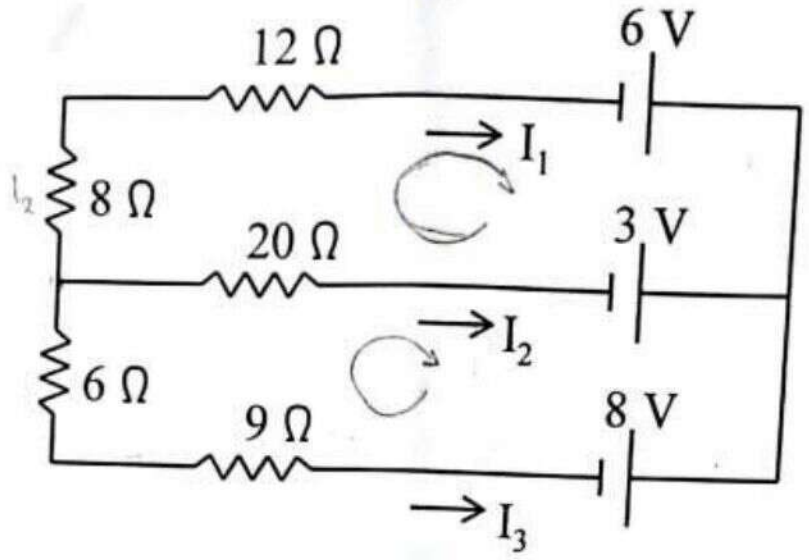


Figure 7.2

&&&&&&&&&&&&&&&&&&&&&&&&&&&& GOOD LUCK &&&&&&&&&&&&&&&&&&&&&&&&&&&&

THE COPPERBELT UNIVERSITY

SCHOOL OF MATHEMATICS AND NATURAL SCIENCES

PHYSICS DEPARTMENT

2016/2017 ACADEMIC YEAR

PH 110 TEST 1

TIME: TWO (2) HOURS

INSTRUCTIONS: THERE ARE FIVE (5) QUESTIONS IN THIS PAPER, ATTEMPT ANY FOUR (4) QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

MAXIMUM MARKS: **100**

USE THE FOLLOWING DATA WHERE NECESSARY:

Acceleration due to gravity, $g = 9.8\ m/s^2$

QUESTION 1

a. Two vectors are given by $\vec{A} = 3\hat{\imath} - 2\hat{\jmath} - 3\hat{k}$ and $\vec{B} = 3\hat{\imath} - 2\hat{\jmath} + 3\hat{k}$

i. Define the cross [vector] product of these two vectors. [3]

ii. Let $\vec{C} = \vec{A} \times \vec{B}$ [a vector product], Find

a. the vector $\vec{C}$ **[3]**

b. the magnitude of vector $\vec{C}$ [2]

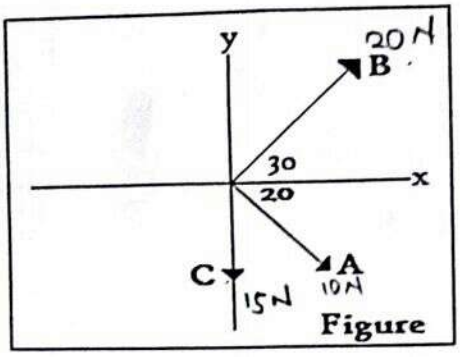
c. the unit vector of in the direction of vector $\vec{C}$. [2]

b. Find the components of a displacement which when added to a displacement of $[7\hat{\imath}-4\hat{\jmath}]$ will give a resultant displacement of $[5\hat{\imath} - 3\hat{\jmath}]$ [4]

c. A force $\vec{A}$ is added to a second force which has x and y components 3N and -5N. The resultant of the two forces is in the - x direction and has a magnitude of 4N. Find the x and y components of $\vec{A}$. **[4]**

d. Three vectors are oriented as shown in figure below, where $\vec{A}$ =10N, $\vec{B}$ = 20N and $\vec{C}$ =15N.

Find the x and y components of the resultant vector $\vec{D} = \vec{A} - \vec{B} + \vec{C}$ [3]



Figure

e. When vector $\vec{B}$ is added to vector $\vec{A}$ we get $[5\hat{\imath} - \hat{\jmath}]$ and when vector $\vec{B}$ is subtracted from $\vec{A}$ we get $[\hat{\imath} - 7\hat{\jmath}]$, what is the magnitude and direction of $\vec{A}$? [4]

QUESTION 2

A. A pendulum suspended from the roof of a bus moving along a horizontal track makes an angle of 5° with the vertical.

(i) What forces are acting on the pendulum bob? [4 marks]

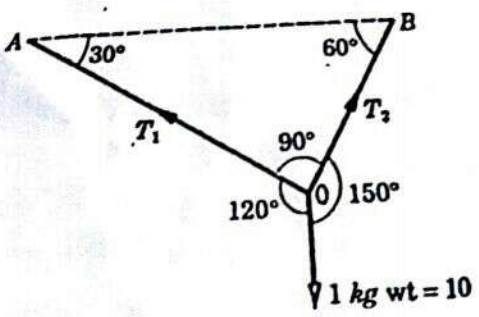
(ii) Determine the acceleration of the bus. [9 marks]

B. A ball of mass $1\,kg$ hangs in equilibrium from two strings OA and OB as shown in the figure below.

(i) Define concurrent forces? [2 marks]

(ii) Define moment of a force. [2 marks]

(iii) Determine ~~are~~ the tensions in the strings OA and OB? [8 marks]



QUESTION 3

(a) (i) Explain the principle of homogeneity of dimensions [3]

(ii) State two limitations of dimensional analysis. [2]

(b) The velocity $v$of a particle varies with time$t$according to the relation$v = at^2 + bt + c$. Find the dimensions of a, b and c. [4]

(c) Stoke's formula gives an expression for the viscous force F acting on a small sphere moving through a homogeneous viscous fluid. The magnitude of F depends on the viscosity η of the liquid, the radius r of the sphere and the velocity v of the sphere. Use dimensional analysis to derive Stoke's formula. (Units of η are kg $m^{-1}s^{-1}$) [7]

(d) Astronomical distances are sometimes described in terms of light-years. A light-year (ly) is the distance that light will travel in one year. How far in metres does light travel in a quarter year if the speed of light is 3×10^8 ms^{-1}? [4]

(e) Density is defined as mass per unit volume. A crude estimation of the average density of the earth was 5.5 g/cm^3. Express this density in kg/m^3. Hence calculate the mass of the earth in kilograms if the earth is considered to be a sphere of radius 6370 km. [5]

QUESTION 4

(a) You are standing on an observation deck 100 m above a city street and drop a rock from rest.

A friend stands on the street directly below you and throws a rock vertically upward at the same instant that you drop the rock. The initial upward velocity of his rock is 50 m/s.

Assuming that they are moving along the same vertical line, and that air resistance can be neglected, calculate:

(i) the height at which they will collide, [4]

(ii) when they will collide, and [2]

(iii) whether your friend's rock will be rising or descending when they collide. [2]

(b) A railcar is moving horizontally with a speed of 24 m/s and decelerating at 3.65 m/s^2 when a light bulb 2.55 m above the floor comes loose and drops. Where, relative to the point directly below its original position, will the bulb strike the floor? [9]

(c) (i) An elevator in which a woman is standing is moving upward with a constant speed of 3.35 m/s. The woman drops a coin from a height of 1.25 m above the elevator floor. How long does it take the coin to strike the elevator floor? [4]

(ii) If the elevator was at rest at the instant the coin was dropped, but is accelerating upward at 3.5 m/s^2, how long would it take the coin to strike floor? [4]

QUESTION FIVE

a. Explain the following terms: [2,2,2]
   i. Inertia
   ii. Weight
   iii. dynamics

b. Which of Newton's laws is referred to as the Principle of Inertia? What does it state? [3]

c. Consider a block of mass 10 kg placed on a rough surface inclined at 30 degrees. If the coefficient of static friction is 0.20, calculate its acceleration if let free. [5]

d. A ball of mass m_1 and a block of mass m_2 are attached by a lightweight cord that passes over a frictionless pulley of negligible mass, as in Figure 5.1. The block lies on a frictionless incline of angle θ. Find the magnitude of the acceleration of the two objects and the tension in the cord in terms of m_1, m_2 and θ. [7]

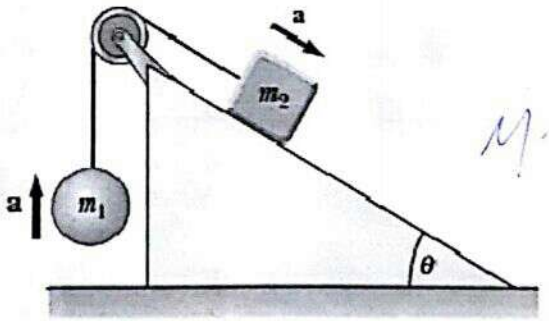


Figure 5.1

e. A flat piece of polished wood is pulled by a 70 N force at an angle of 20 degrees above the horizontal. The polished wood is 25 kg and the surface is smooth. What acceleration does the piece of would acquire and what velocity does it move with after 1 minute from the time the force begins to act on it? [4]

THE COPPERBELT UNIVERSITY

SCHOOL OF MATHEMATICS AND NATURAL SCIENCES

PHYSICS DEPARTMENT

2016/2017 ACADEMIC YEAR

DEFERRED SESSIONAL EXAMINATIONS

PH 110: INTRODUCTORY PHYSICS - I

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER ANY FIVE (5) QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS. THE MARKS ARE SHOWN IN BRACKET. CLEARLY INDICATE THE QUESTIONS YOU HAVE ATTEMPTED ON THE COVER PAGE OF YOUR ANSWER BOOKLET.

MAXIMUM MARKS: 100

DO NOT FORGET TO WRITE YOUR STUDENT IDENTIFICATION NUMBER (S.I.N) ON THE ANSWER BOOKLET!

USE THE FOLLOWING DATA WHERE NECESSARY:

Acceleration due to gravity, $g = 9.80\ m/s^2$

Universal gravitational constant, $G = 6.67\times10^{-11}\ Nm^2Kg^{-2}$

Mass of electron, $m_e = 9.11\times10^{-31}\ kg$; Mass of proton, $m_p = 1.67\times10^{-27}\ kg$

$k = 9.0\times10^{9}\ Nm^2C^{-2}$; Electronic charge, $e = 1.6\times10^{-19}\ C$;

Moment of inertia of solid sphere, $I = \frac{2}{5}mr^2$; Mass of Mars, $M_{Mars} = 6.42\times10^{23}\ kg$

Radius of Mars, $R_{Mars} = 3.37\times10^{6}\ m$

QUESTION ONE

(a) A famous relation in Physics relates moving mass m to rest mass m_0 in terms of its speed v and the speed of light c. A boy recalls the relational most correctly but forgets where to put the constant c. He writes as $m = \frac{m_0}{\sqrt{(1-v^2)}}$.

Guess where to put c and give two reasons for your guess? [3 marks]

(b) A Physical quantity P is related to four observables a, b, c and d as follows;

$$P = a^3 b^2 / \sqrt{cd}$$

The percentage errors of measurement in a, b, c, and d are 1%, 3%, 4% and 2% respectively.

(i) What is the percentage error in the quantity P? [5 marks]

(ii) If the value of P calculated using this relation turns out to be 3.763, to what value should you round off the result? [2 marks]

(c) A hiker walks 53.1 degrees north of east for 2.5km then due east for 2.0km. What is her total displacement from her starting point if you measure the distance along a straight line? [4 marks]

(d)

(i) Define a dot product of two vectors? [2 marks]

(ii) What is the angle between the vectors $\vec{A} = 2\hat{i} - 3\hat{j} + 4\hat{k}$ and $\vec{B} = -2\hat{i} + 5\hat{j} - 3\hat{k}$? [4 marks]

QUESTION TWO

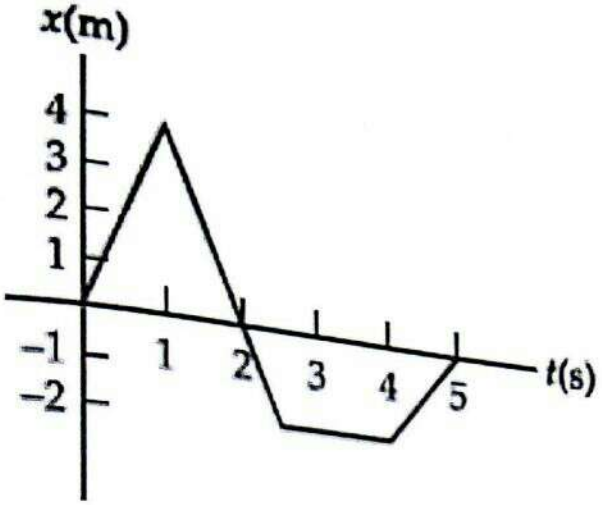
(a) A tennis player moves in a straight-line path as shown in the Figure below. Find her average velocity in the time intervals from

(i) 0 to 1.0 s [1.5 marks]

(ii) 0 to 4.0 s [1.5 marks]

(iii) 1.0 s to 5.0 s [1.5 marks]

(iv) 0 to 5.0 s [1.5 marks]



(b) A river has a steady speed of 0.50 m/s. A student swims upstream a distance of 1.0 km and swims back to the starting point. If the student can swim at a speed of 1.20 m/s in still water, how long does the trip take?

[7 marks]

(c) If a person can jump a maximum horizontal distance (by using a 45° projection angle) of 3.0 m on Earth, what would be his maximum range on the Moon, where the free-fall acceleration is g/6?

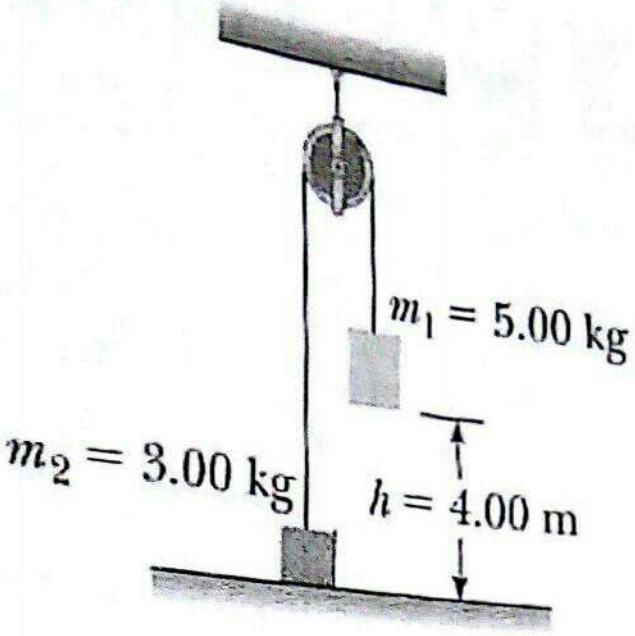
[7 marks]

QUESTION THREE

(a) Two objects are connected by a light string passing over a light, frictionless pulley as shown in the Figure below. The 5.0 kg object is released from rest at a point 4.0 m above the floor.

(i) Determine the speed of each object when the two pass each other. [5 marks]

(ii) Determine the speed of each object at the moment when the 5.0 kg object hits the floor. [5 marks]

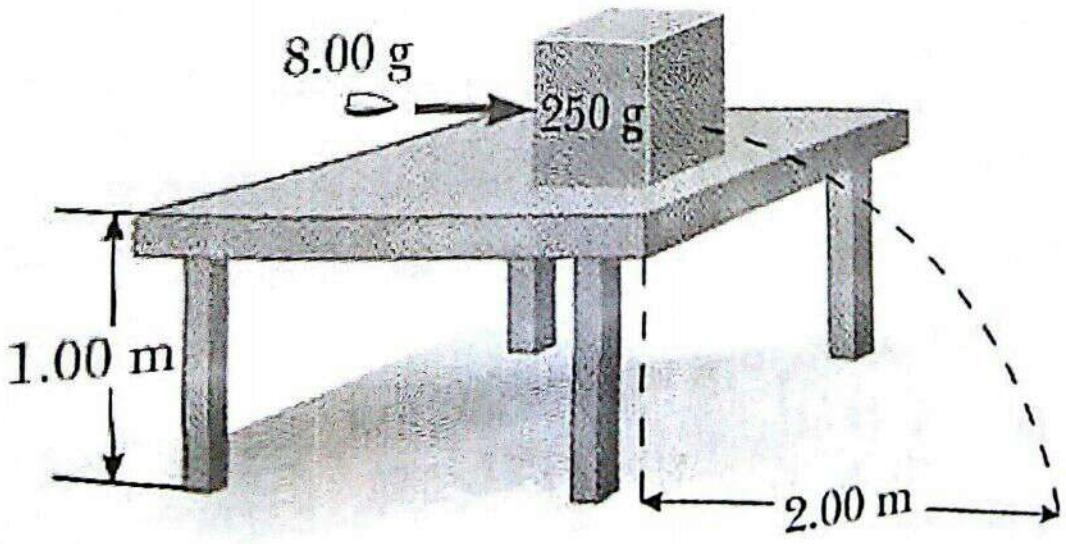


(b) If the speed of a particle is doubled,

(i) By what factor is its momentum changed? [1.5 marks]

(ii) By what factor is its kinetic energy changed? [1.5 marks]

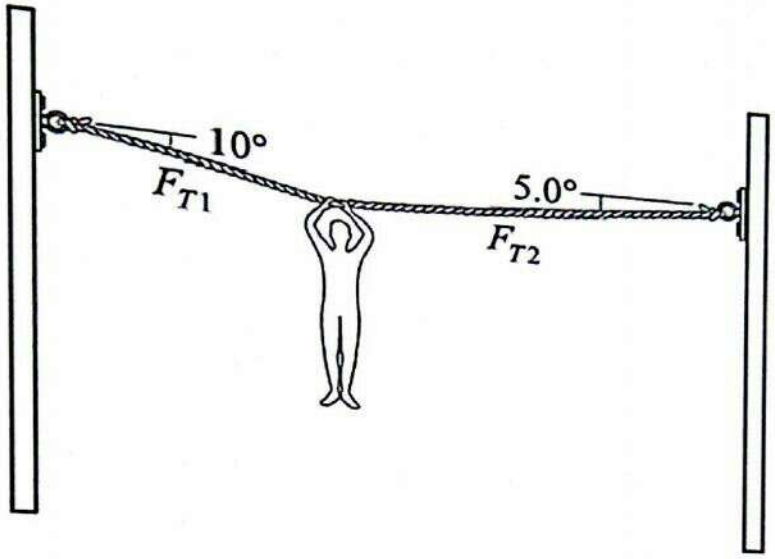
(c) An 8.0 g bullet is fired into a 250 g block that is initially at rest at the edge of a table of height 1.0 m as shown the Figure below. The bullet remains in the block, and after the impact the block lands 2.0 m from the bottom of the table. Determine the initial speed of the bullet. [7 marks]



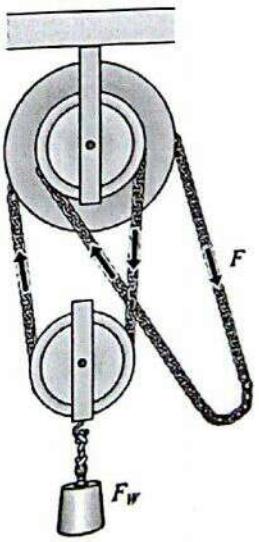
QUESTION FOUR

(a) A rope extends between two poles. A $90N$ boy hangs from it as shown in the figure below. Find the tensions in the two parts of the rope.

[10 marks]



(a) A differential pulley (chain hoist) is shown below. Two toothed pulleys of radii $r = 10$ cm and $R = 11$ cm are fastened together and turn on the same axle. A continuous chain passes over the smaller (10 cm) pulley, then around the movable pulley at the bottom, and finally around the 11 cm pulley. The operator exerts a downward force F on the chain to lift the load F_W.



[4 marks]

(i) Determine the IMA,

(ii) What is the efficiency of the machine if the applied force of 50 N is required to lift a load of $700N$?

[6 marks]

QUESTION FIVE

(a) Mars rotates on its axis once every 1.02 days (almost the same as Earth does).

(i) Find the distance from Mars at which a satellite would remain in one spot over the Martian surface.

[6 marks]

(ii) Find the speed of the satellite.

[4 marks]

(b) A student rides a bicycle with a wheel diameter of 1.0 m to campus. A piece of plastic on the front rim makes a clicking sound every time it passes through the fork. If the student counts 640 clicks between her boarding house and the lecture theatre, how far has she traveled?

[3 marks]

(c) A woman places her briefcase on the backseat of her car. As she drives to work, the car negotiates an unbanked curve in the road that can be regarded as an arc of a circle of radius 62.0 m. While on the curve, the car's speedometer registers 15.0 m/s at the instant the briefcase starts to slide across the backseat towards the side of the car.

(i) What force causes the centripetal acceleration of the briefcase when it is stationary relative to the car?

[2 marks]

(ii) What is the coefficient of static friction between the briefcase and the seat surface?

[5 marks]

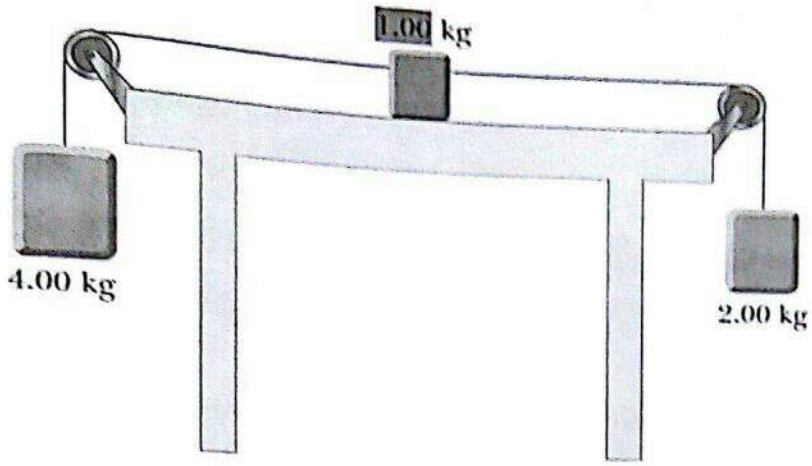
QUESTION SIX

(a)Three objects are connected on the table as shown in the figure below. The table is rough and has a coefficient of kinetic friction of 0.35. The objects have masses of 4.00 kg, 1.00 kg, and 2.00 kg, as shown, and the pulleys are frictionless.

[3 marks]

(i) Draw free-body diagrams of each of the objects.

(ii) Determine the acceleration of the system and the tensions in the two cords [7 marks]



(b) A wheel rotates in such a way that its angular acceleration α as a function of time t is given by:

$$\alpha = 6at - 2b.$$

where a and b are constants

At $t = 0$, the wheel has an angular speed ω_0 and angular position θ_0. Determine the equations for the angular speed ω and angular position θ as a function of time t. [5 marks]

(c) Consider a solid sphere of radius r and mass m initially at rest on an inclined surface. Show that if the sphere rolls without slipping from a height h, it reaches the bottom of the incline with speed [5 marks]

$$v = \sqrt{\frac{10gh}{7}}$$

QUESTION SEVEN

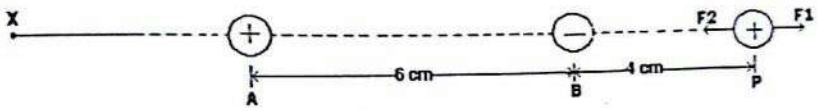
(a) State the Coulombs law for the two point charges q_1 and q_2, separated by a distance 'r' in free space. [3 marks]

(b) Write this force in vector form.

[2 marks]

(c) The diagram below shows three small charges q_1, q_2 and q_3 are placed at points A, B and P in a straight line. The charge at A is positive, that at B is negative and that at P is positive. The values are as follows;

$q_1 = +3\ \mu C$, $q_2 = -6\ \mu C$ and $q_3 = 2\ \mu C$.



(i) Calculate the force on the charge at P due to the charges at A and B [4 marks]

(ii) At what point **X** on the line AB could there be **NO** force on the charge q_3 due to q_1 and q_2 if q_3 were placed there? [6 marks]

(d) A wire that has a resistance of 5 ohms is passed through an extruder so as to make it into a new wire three times as long as the original. What is the new resistance? [5 marks]

&&&&&&&&&&&&&&&&&&&&&&&& *GOOD LUCK* &&&&&&&&&&&&&&&&&&&&&&&&

THE COPPERBELT UNIVERSITY

SCHOOL OF MATHEMATICS AND NATURAL SCIENCES

DEPARTMENT OF PHYSICS

SESSIONAL EXAMINATION 2015/2016 ACADEMIC YEAR

PH 110

PHYSICS

INSTRUCTIONS:

- There are **SEVEN (7)** questions in this examination paper, answer **any five questions of your choice**, all questions carry equal marks.

Write the following on the front page of your answer booklet:

- Student Identification Number (SIN)
- Your Group (For Non Quota) or Programme of Study (For students from the School of Natural Resources).
- Marks are shown in the square brackets. Ma

DURATION: **Three (3) Hours** **Maximum marks = 100**

CONSTANTS:

1. Acceleration due to gravity $g = 9.81\ m.s^{-2}$
2. Electrostatic constant $k = 9 \times 10^9\ N.m^2/C^2$

SOME USEFUL FORMULA

$$R = \rho\frac{L}{A},\quad F_g = -G\frac{M_1 m_2}{r^2},\quad F = k\frac{q_1 q_2}{r^2},\quad W = \mathbf{F}\bullet\Delta\mathbf{r} = F\,\Delta r\cos\theta,\quad W = \int_{x_i}^{x_f} F_x dx$$

Where necessary, use:

1.0 inch =2.54 cm, 1.609 km = 1.0 miles, 7.48 gallons =0.0283 m^3, 1.0 cm^3=1.0 ml,

746 W = 1.0 horsepower, 1000 kg = 1.0 tones.

QUESTION ONE

(a) The mass of the parasitic wasp can be as small as 5 x 10^{-6} kg. What is this mass in

(i) grams (g) (ii) milligrams (mg) (iii) micrograms (μ g) [6]

(b) In the gas equation $\left(p+\frac{a}{v^2}\right)(v-b)=RT$, where p is the pressure, v is the volume, R is the universal gas constant and T is the temperature, what are the dimensions of a and b? [6]

(c) Suppose that two quantities G and F have different dimensions. Determine which of the following operations could be physically meaningful:

(i) $G+F$ (ii) G/F (iii) $F-G$ (iv) GF [2]

(d) The square of the speed of an object undergoing a uniform acceleration a is some function of a and the displacement s, according to the expression given by:

$$v^2 = ka^x s^y$$

where k is a dimensionless constant. Show by dimensional analysis that this expression is satisfied only if $x = y = 1$. [6]

QUESTION TWO

(a) Find the vector sum of the following four displacements on a map or a graph paper, 60mm north, 30 mm west, 40 mm at 60^0 west of north, and 50 mm at 30^0 west of south. [4]

(b) If $\bar{A} = 2\hat{\imath} - 3\hat{\jmath} + 5\hat{k}\ \ mm$ and $\bar{B} = -\hat{\imath} - 2\hat{\jmath} + 7\hat{k}$ mm, find

(i) $\bar{A} - \bar{B}$ [2]

(ii) $\bar{B} - \bar{A}$ [2]

(iii) Find vector $\bar{C}$, such that $\bar{A} + \bar{B} + \bar{C} = 0$ [3]

(c) Two vectors are given by $\vec{A} = \left(4\vec{i} - \vec{j} + -3\vec{k}\right)$ and $\vec{B} = \left(3\vec{i} - 2\vec{j} + 3\vec{k}\right)$.

(i) Define the dot (scalar) product of two vectors. [1]

(ii) Let the dot (scalar) product between $\vec{A}$ and $\vec{B}$ be vector $\vec{D}$. Find the dot (scalar) product $\vec{D}$ and the angle between vectors $\vec{A}$ and $\vec{B}$ [2,2]

(d) Let $\bar{A} = 20\hat{\imath} - 10\hat{\jmath} + 30\hat{k}$ and $\bar{B} = -6\hat{\imath} + 15\hat{\jmath} - 25\hat{k}$, find:

(i) the vector product $\bar{C} = \bar{A} X \bar{B}$ [2]

(ii) the magnitude of $\bar{C}$ [2]

QUESTION THREE

(a) A projectile is launched from ground level to the top of a 155 m high cliff which is 195 m away as shown in the Figure 1. If the projectile lands on top of the cliff 7.6 s later after it was fired, find the magnitude and direction of the initial velocity of the projectile. Ignore air resistance. [7]

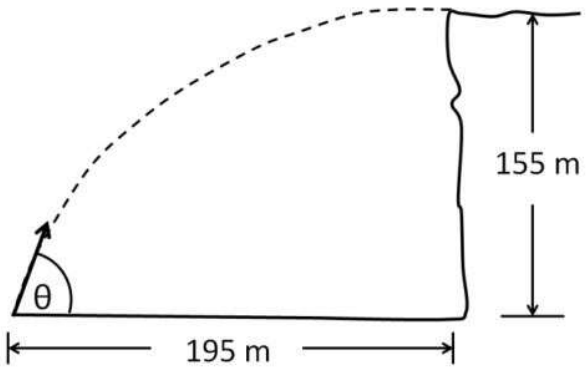


Figure 1

(b) A car travelling at a constant speed of 70 kmh^{-1} passes a stationary police car. The police car immediately gives chase, accelerating uniformly to reach a speed of 85 kmh^{-1} in 10 s and continues at this speed until it overtakes the other car. Find:

(i) The time taken by the police to catch up with the car. [7]

(ii) The distance travelled by the police car when this happens. [2]

(c) Ball *A* falls freely from the top of a 80 m high tower and ball *B* is thrown from the ground vertically upward at the same time as shown in figure 2. If the balls collide after 2s, find the initial velocity of object *B*. [4]

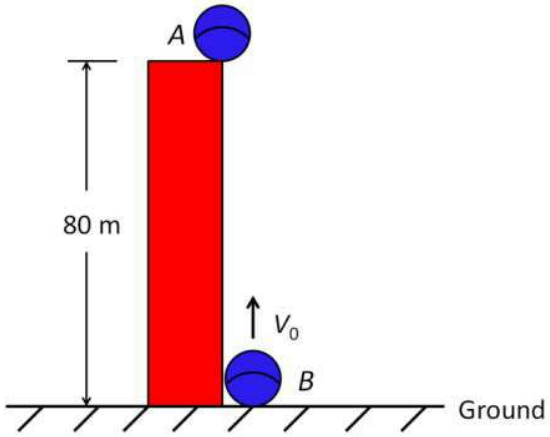


Figure 2

QUESTION FOUR

(a) On planet X, an object weighs 10 N. On planet B, where the acceleration due to gravity is 1.6g, the object weighs 27 N. What is the mass of the object and what is the acceleration due gravity (in m/s^2) on planet X? Comment on the result. [2, 2, 2]

(b) A rifle bullet with a mass of 12 g and travelling with a speed of 400 m/s, strikes a large wooden block, which it penetrates to a depth of 15 cm. Determine the magnitude of the frictional force (assumed constant) that acts on the bullet. Explain your answers. [2, 2, 2]

(c) A block moves up a 45^0 incline with constant speed under the action of a force of 15 N applied parallel to the incline.

(i) Show the forces acting on the block. [2]

(ii) If the coefficient of kinetic friction is 0.3, determine the weight of the block. [6]

QUESTION FIVE

(a) The momentum of a 1250 kg car is equal to the momentum of 5000 kg truck travelling at a speed of 10 km/s. What is the speed of the car? [2]

(b) An estimated force-time curve for a hockey puck struck by a bat is shown in figure 3. From this curve, do the following:

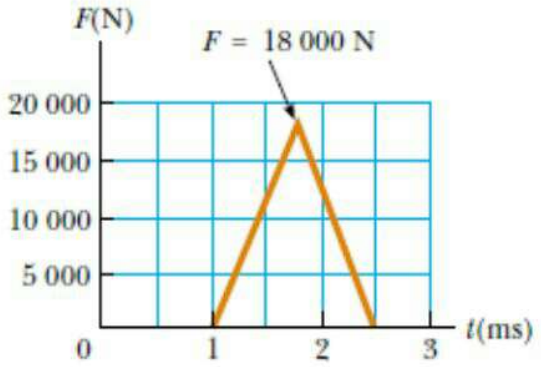


Figure 3

(i) Determine the impulse delivered to the puck [3]
(ii) Find the average force exerted on the puck [3]
(iii) What is the peak force exerted on the puck and comment as to its duration? [2]

(c) A 75 kg ice skater moving at 10 m/s crashes into a stationary skater of equal mass. After the collision, two skaters move as a unit at 5 m/s. The average force that the skater can experience without breaking a bone is 4.5 kN. If the impulse time is 0.01 s, does a bone break?. Your reasoning should be supported by calculations. [10]

QUESTION SIX

(a) An elevator cab of mass 500 kg is descending with a speed of $v_i = 4.0m/s$ when its supporting cable begins to slip, allowing it to fall with a constant acceleration $\vec{a} = \vec{g}/5$

(i) During the fall through a distance d of 10 m, what is the work W_g done on the cab by the gravitational force F_g. [2]

(ii) During the 10 m fall, what is the work W_T done on the cab by the upward tension $\vec{T}$ due to the elevator's cable?. [2]

(iii) What is the net work W_{net} done on the cab during the fall?. [2]

(iv) What is the cab's kinetic energy at the end of the 10m fall?. [2]

(b) A force of $\vec{F} = (6x^2N)\hat{i} + (4N)\hat{j}$ acts on a particle that moves from coordinates (2 ,2) m to (3,4) m changing only the kinetic energy of the particle.

(i) How much work is done on the particle as it moves from coordinates (2 ,2) m to (3,4) m ?. [4]

(ii) Does the speed of the particle increase, decrease or remain the same? Give a reason for your answer. [2]

(c) Consider a machine for which an applied force moves 3.5 m to raise a load by 9 cm. Find

(i) IMA [2]

(ii) AMA if the efficiency is 75%. [2]

(iii) What load can be lifted by an applied force of 60 N if the efficiency is 75% [2]

QUESTION SEVEN

(a) State Ohm's law [1]

(b) Define the resistivity of a wire [2]

(c) A battery of EMF 1.5 volts and internal resistance of 0.2 ohms, is connected to a set of two resistors 2 ohms and 3 ohms. Calculate the current in the circuit when

(i) the resistors of 2Ω and 3Ω are connected in series [2]

(ii) the resistors of 2Ω and 3Ω are connected in parallel [3]

(d) A test charge Q = + 2μC is placed halfway between a charge Q_1 = + 6 μC and a charge Q_2 = + 4 μC, which are 10 cm apart. Find the force on the charge Q. [4]

(e) A metal rod is 3 m long and 6 mm in diameter. Compute its resistance if the resistivity of the metal is $1.86 \times 10^{-8}\ \Omega.m$ [4]

(f) In the Bohr model, the electron of a hydrogen atom moves in a circular orbit of radius 5.25×10^{-11} m with a speed of 2.195×10^{6} m.s^{-1}. Determine its frequency 'f ' and the current ' I 'in the orbit. [4]

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THE COPPERBELT UNIVERSITY

SCHOOL OF MATHEMATICS AND NATURAL SCIENCES

DEPARTMENT OF PHYSICS

SCHOOL OF MEDICINE (NDOLA CAMPUS)

MPH 110 (INTRODUCTORY PHYSICS) TEST ONE

Duration: Two hours **Date: 20th March 2019.** **Total Marks: 100**

Instructions

1. Answer all the four questions in the question paper
2. Omitting of essential working will lead to loss of marks
3. All questions carry equal marks
4. This paper consist of three pages

Useful formulae and constant

1. $H = \frac{V_o^2}{2g} Sin^2\theta$
2. $R = \frac{V_o^2}{g} \text{Sin } 2\theta$
3. $T = \frac{2V_o}{g} Sin\theta$
4. $g = 9.81 m/s^2$

Question One

a. State two limitation of dimensional analysis. [2]

b. A students closes the windows and doors of his room, he then switches on an upright freezer and opens its door (the freezer was off and completely empty). He is doing this so that he can cool his room, explain why his method may not work (why the room will not be cool). [2]

c. Astronomical distances are sometimes described in terms of light-years (ly). A light-year is the distance that light will travel in one year (yr). How far in meters does light travel in one year? (Given that c =299,792,458m/s). [4]

d. A given standard unit cell of silicon has a volume V_o and contains N_o atoms. The number of molecules in a given mole of substance is given by Avogadro's constant $N_A = 6.02214129 \times 10^{23}$ mol^{-1}. The molar mass of silicon is given by M_{mol}. Find the mass m of a volume V in terms of V_o, N_o, V, M_{mol} and N_A. [9]

e. The speed (v) of sound in a gas might plausibly depend on the pressure (P), the density (ρ) and the volume (V) of the gas. Use dimensional analysis to determine the exponents x, y and z in the formula.

$$v = CP^x \rho^y V^z$$

Where C is a dimensionless constant and the units for pressure (P) is ($kg/m.s^2$) [8]

Total: 25 marks

Question Two

a. Find the angle between two equal forces **B**, if there resultant is **B**. [3]

b. The resultant of two forces **P** and **Q** is **R**. If **Q** is doubled, the new resultant is perpendicular to **P**. Prove that **Q** = **R**. [6]

c. When displacement **B** is added to displacement **A** the result is a displacement **C** that has components C_x= -3.7cm, C_y= 2.25cm and C_z = 4.6cm. Displacement **A** and **B** are in the same direction, but the magnitude of **A** is only one-third that of **B**. Find the components of **A**. [8]

d. A vector **B** (in 2D), when added to the vector **C** = 3.0i + 4.0j, yields a resultant vector that is in the positive y - direction and has a magnitude equal to that of vector **C**. What is the magnitude of **B**? [8]

Total: 25 marks

Question Three

a. A body freely falling under the action of gravity passes two points 10 metres apart vertically in 0.2s. From what height, above the higher point did it start to fall? [6]

b. Two electric trains A and B leave the same station in parallel lines. Train A starts from rest with uniform acceleration of $0.2m/s^2$ attains a speed of 45km/h, which it maintains constant afterwards. Train B leaves 1 minute after with a uniform acceleration of $0.4m/s^2$ attain a maximum speed of 72km/h, which is maintained constant afterwards. When will train B overtake train A? [9]

c. An archer shoots an arrow with a velocity of 45.0m/s at an angle of 50° with the horizontal. An assistant standing on the level ground 150m down range from the launch point throws

an apple straight up with the minimum initial speed necessary to meet the path of the arrow.

i. What is the initial speed of the apple? [6]

ii. At what time after the arrow launch should the apple be thrown so that the arrow hits the apple? [4]

Total: 25 marks

Question Four

a. The equation of motion a car 1200kg moving in a straight line is given by:

$$s = 18t + 2t^2 - 2t^3$$

Where: (s) is in metres and (t) is in seconds.

i. Find the displacement, velocity and the acceleration of the car after 5s. [6]

ii. If the coefficient of friction between the tires and the road is 0.5, find the driving force produced by the engine at t 5s? [6]

b. In figure 4.0. The coefficient of static friction between the 200g and 50g mass is 0.3. The 200g mass is free to move along a frictionless horizontal table: A string connects the 200g mass to mass M_1 via a frictionless pulley as shown in figure 4.0.

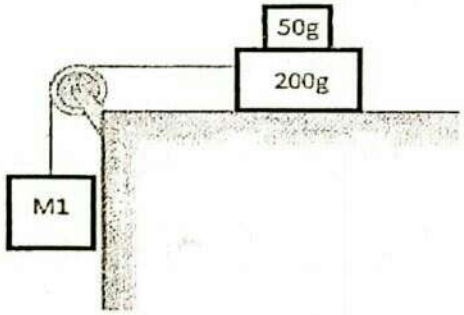


Figure 4.0

What is the largest value of M_1 for which the 50g mass will remain on top of the 200g mass as the system accelerates? [10]

c. The systems shown in Figure 4.1 are in equilibrium. If the spring scales are calibrated in Newtons, what do they read? (Neglect the masses of the pulleys and strings.) [3]

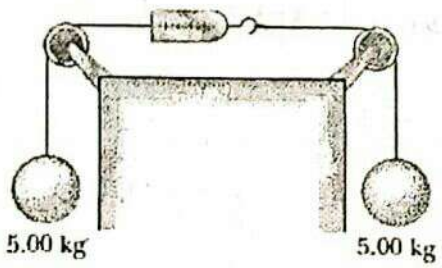


Figure 4.1

Total: 25 marks

End of Test

THE COPPERBELT UNIVERSITY

SCHOOL OF MEDICINE

DEPARTMENT OF PREMEDICAL

NDOLA CAMPUS

MPH 110 (INTRODUCTORY PHYSICS) TEST TWO (2)

Duration: Two hours **JUNE 2019.** **Total Marks: 100**

Instructions

1. Answer all the four questions in the question paper
2. Omitting of essential working will lead to loss of marks
3. All questions carry equal marks
4. This paper consist of four (4) printed pages.

Constants

1. $g = 9.8 m/s^2$
2. 1 hp = 746 W
3. $1 eV = 1.602 \times 10^{-19} J$
4. 1 Kcal = 4184 J
5. 1 tonne = 1000 kg

Question One

a. A stream of elastic glass beads, each with a mass of 0.50 g, comes out of a horizontal tube at a rate of 100 per second. The beads fall a distance of 0.50 m to a balance pan and bounce back to their original height.

i. Draw a free body diagram to show what is happening [2]

ii. What is the y - component of the velocity as glass beads hits the scale pan of the balance? [4]

iii. Find the change in momentum and hence expression for the net force exerted on the pan in the y-direction only. [6]

iv. How much mass must be placed in the other pan of the balance to keep the pointer at zero? [5]

b. Two halves of a round homogeneous cylinder are held together by a thread wrapped round the cylinder with two weights each equal to P attached to its ends as shown in Fig 1.0,

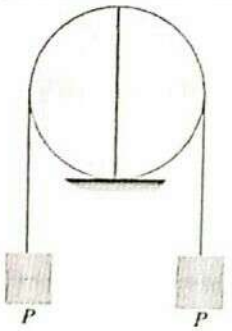


Fig 1.0

The complete cylinder weighs W newton. The plane of contact of both of its halves is vertical. Determine the minimum value of P, for which both halves of the cylinder will be in equilibrium on a horizontal plane. Given that the centre of gravity of a semi-circle is at a distance of $4r/3\pi$ from its base measured along the radius. [8]

Total: 25 marks

Question Two

a. State two conditions that must be satisfied for a system to be in static equilibrium [2]

b. The following experiment is performed. A 0.250 kg object is slid on a frictionless surface into a dark room, where it strikes an initially stationary object with mass of 0.400 kg. The 0.250 kg object emerges from the room at an angle of 45.0^0 with its incoming direction. The speed of the 0.250 kg object is originally 2.00 m/s and is 1.50 m/s after the collision. Calculate the magnitude and direction of the velocity of the 0.400 kg object after the collision. [7]

c. If the tension T_1= 100N, find the weight W in fig 2.0 [3]

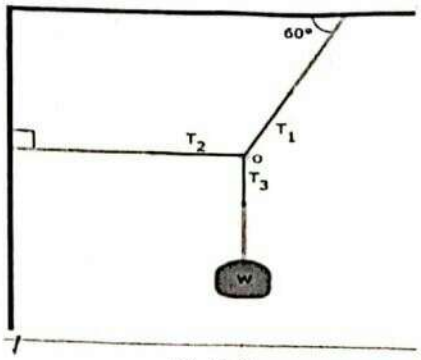


Fig 2.0

d. Consider a pulley system shown in fig 2.1.

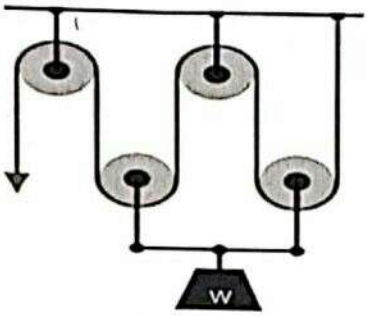


Fig 2.1

i. What is the IMA of the system? [2]

ii. What is the efficiency of the system if the AMA is 3? [2]

III. What load can be lifted by 10 N effort? [2]

e. An egg of mass 50g drops from the edge of a table of height 1m and splatters on the floor. Assuming that the eggs travels 2cm after impact with the floor. Find;

i. The change in momentum [3]

ii. The average force exerted by the floor on the egg [4]

Total: 25 marks

Question Three

a. A bullet of mass m is fired into a block of mass M initially at rest at the edge of a frictionless table of height h as shown in the Figure 3.0.

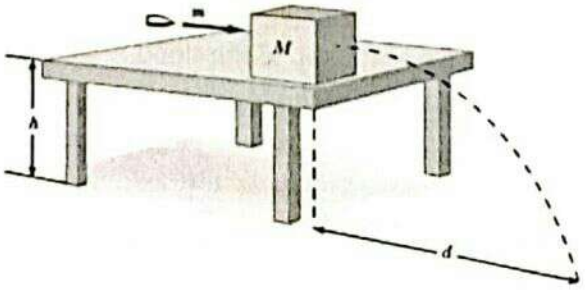


Figure 3.0

The bullet remains in the block, and after impact the block lands a distance d from the bottom of the table. Determine the initial speed of the bullet. [8]

b. A Saturn V rocket's mass at lift off was M = 2.80×10^6 kg , its fuel-burn rate was $\left(\frac{\Delta m}{\Delta t}\right) = 1.40\times10^4$ kg/s , and the exhaust velocity (v) was 2.40×10^3 m/s. The approximate acceleration at lift off is given by:

$$a = \frac{v}{M}\left(\frac{\Delta m}{\Delta t}\right) - g$$

i. Why is this value considered to be an approximation? [2]

ii. Find the approximate initial acceleration of the rocket? [1]

c. An engine of mass 50 tonnes pulls a train of mass of 250 tonnes up a slope with angle of 0.46^0 with the horizontal, the coefficient of friction on the rails 0.36 and we assume no air resistance or any other energy loses. It can starts from rest and attains a speed of 10m/s covering a distance of 250m when working at maximum power.

i. Draw a free body diagram to show the forces acting on the train and engine. [3]

ii. What how long does it take to cover the 250m distance? [2]

iii. Find the work done by the engine when it moves through a distance of 250m [8]

iv. Find the maximum power of the engine [1]

Total: 25 marks

Question Four

a. State the law of conservation of energy [2]

b. A 0.100kg toy car is propelled by a compressed spring as shown in fig 4.0. The spring is lying on a horizontal surface, the car follows the track that rises 0.18m above the starting point.

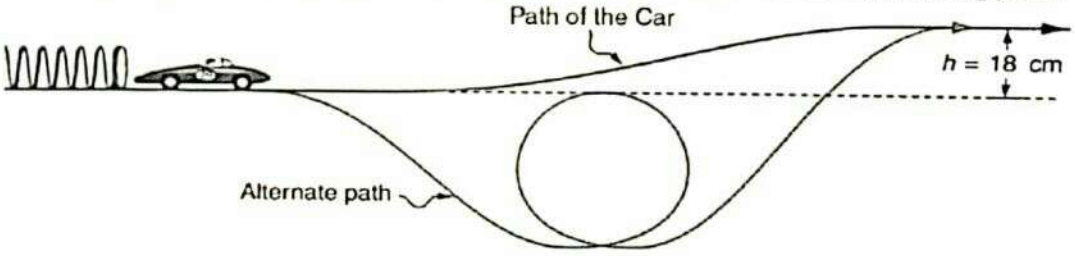


Figure 4.0

The spring is compressed 4.00cm and has a spring constant of 250N/m. Assuming work done by friction is negligible. Find

i. How fast the toy car is moving before its starts up the slope [5]

ii. How fast it is moving at the top of the slope. [8]

iii. How fast will it be moving at the top of the slope if it took the alternative path? [2]

c. A person who normally requires an average of 12000 KJ of food energy per day consumes 13000KJ per day, he will steadily gain weight. (Given that; power consumption when cycling at moderate speed is 400W and assume that a 1.0g of fat contains 39KJ of energy).

i. How much bicycling per day is required to work off this extra 1000KJ [5]

ii. What is the approximate weight gain per day if he does not exercise? [3]

Total: 25 marks

End of Test

QUESTION ONE

(a) An astronomical unit (AU) is the average distance between Earth and the Sun, approximately 1.50×10^8 km. The speed of light is about 3.0×10^8 m/s. Express the speed of light in astronomical units per minute. [5 marks]

(b) The speed v of an object is given by the Equation

$$v = At^3 - Bt$$

where t refers to time. What are the dimensions of A and B? [5 marks]

(c) A golfer takes three putts to get the ball into the hole. The first putt displaces the ball 3.66 m north, the second 1.83 m southeast, and the third 0.91 m southwest. What are
(i) the magnitude, and [5 marks]
(ii) the direction of the displacement needed to get the ball into the hole on the first putt? [2 marks]

(d) If $\vec{a} - \vec{b} = 2\vec{c}$, $\vec{a} + \vec{b} = 4\vec{c}$, and $\vec{c} = 3\hat{i} + 4\hat{j}$, then what are vectors $\vec{a}$ and $\vec{b}$? [3 marks]

QUESTION TWO

(a) Define the following terms
(i) Relative velocity [1 mark]
(ii) Projectile [1 mark]
(iii) Variable acceleration [1 mark]

(b) Two trains A and B, each of length 100 m, are moving on parallel tracks. One over takes the other in 20 s (i.e., the front of train A catches up with the rear of train B) and crosses it in 10 s (i.e., the rear of train A catches up with the front of train B). Calculate the velocities of each train. [5 marks]

(c) A ball is thrown at an angle θ and another ball is thrown at an angle of $(90°-\theta)$ with the horizontal direction from the same point with the same velocity of 40 ms^{-1}. The second ball reaches 60 m higher than the first ball. Find their individual heights. [5 marks]

(d) Two cars start off to race with velocities v_1 and v_2 and travel in a straight line with uniform accelerations a_1 and a_2 respectively. If the race ends in a dead heat (i.e., they reach the finishing point at the same time) prove that the length of the course is

$$\frac{2(v_1 - v_2)(v_1 a_2 - v_2 a_1)}{(a_1 - a_2)^2}$$ [7 marks]

QUESTION THREE

(a) The work-energy principle states that the net work done on an object is equal to the change in the object's kinetic energy. Derive an expression for the work-energy principle for a rigid object of mass m that is moving in a straight line with an initial speed v_1 to the final speed v_2 after the application of a constant net force applied parallel to its motion causing the object to accelerate over a displacement d. [5 marks]

(b) A 2 kg block slides across a tabletop with an initial velocity of 25 *m/s* and comes to rest in a distance of 80 *m*. Calculate

(i) the average frictional force that retarded its motion, and [3 marks]

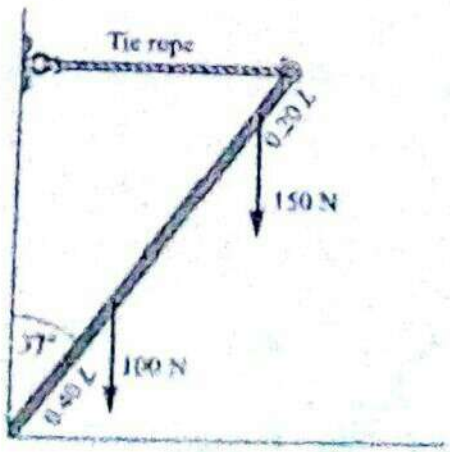
(ii) the coefficient of kinetic friction for the surface of the table. [2 marks]

(c) A ball of mass 0.5 kg is dropped from rest from a height of 1.5 m. It rebounds from the floor to reach a height of 1.2 m. Calculate the impulse that was given to the ball by the floor. [4 marks]

(d) Two balls of equal mass undergo perfectly elastic head-on collision. The initial velocity of the ball travelling east is 0.8 m/s while the initial velocity for the ball travelling west is 0.5 m/s. Calculate the final velocities for each ball. [6 marks]

QUESTION FOUR

(a) The foot of a ladder rests against a wall and its top is held by a tie rope, as shown in the Figure below. The ladder weighs 100 N, and its center of gravity is 040 of length from the foot. A 150 N child hangs from a rung that is 0.20 of the length from the top. Determine the tension in the tie rope and the components of the force on the foot of the ladder. [10 marks]

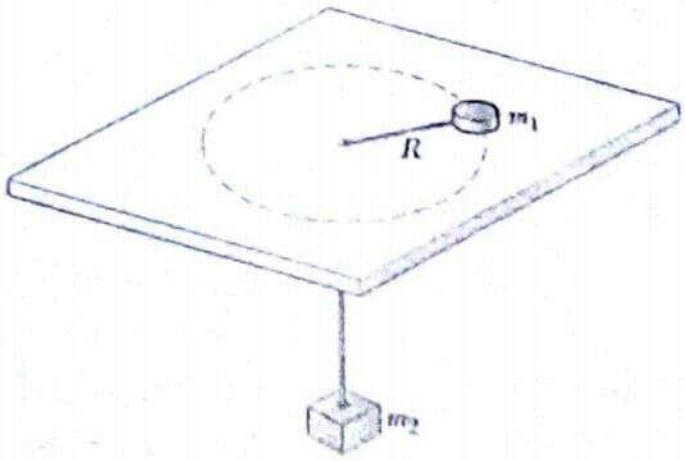


(b) With a wheel and axle, a force of 80 N applied to the rim of the wheel can lift a load of 6[illegible] N. The diameters of the wheel and axle are 36 cm and 4.0 cm respectively. Determine the actual mechanical advantage (AMA), ideal mechanical advantage (IMA) and efficiency of the machine. [10 marks]

QUESTION FIVE

(a) An air puck of mass m_1 is tied to a string and allowed to revolve in a circle of radius R on a frictionless horizontal table. The other end of the string passes through a hole in the center of the table, and a counterweight of mass m_2 is tied to it as shown in the Figure below. The suspended object remains in equilibrium while the puck on the tabletop revolves. What is

(i) the tension in the string? [1 marks]
(ii) the radial force acting on the puck? [2 marks]
(iii) the speed of the puck? [3 marks]



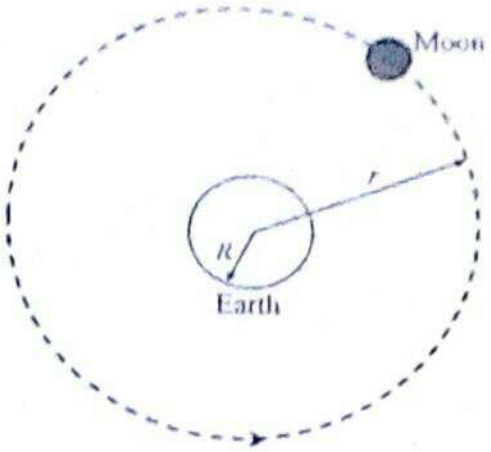
(b) A crate of eggs is located in the middle of the flat bed of a pickup truck as the truck negotiates an unbanked curve in the road. The curve may be regarded as an arc of a circle of radius 35.0 m. If the coefficient of static friction between crate and truck is 0.6, how fast can the truck be moving without the crate sliding? [4 marks]

(c) State Kepler's three laws of planetary motion. [3 marks]

(d) If the moon describes a circular orbit of radius r around the Earth (see Figure below) with uniform angular velocity ω, show that

$$\omega^2 r^3 = gR^2$$

where R is the radius of the Earth. [7 marks]



QUESTION SIX

(a) You are driving along an empty straight road at constant speed v. At some point you notice a child standing in the middle of the road at a distance x in front of you. Show that the magnitude of the average retarding force required to stop the car just in time to save the child is

$$F = M\frac{v^2}{2x}$$

where M, is the combined mass of the driver and the car. [3 marks]

(b) A block of mass $m_1 = 4$ kg lying on a rough horizontal surface is connected to a second block of mass $m_2 = 6$ kg by a light non-stretchable cord over a massless, frictionless pulley as shown in the figure below. The coefficient of kinetic friction between the block and the surface is 0.5. Find the acceleration of the system and the tension in the cord. [7 marks]

(c) A wheel rotates in such a way that its angular displacement θ as a function of time t is given by:

$$\theta = t^3 + 2t^2 - 2$$

where θ is in radians and t is in seconds.

At $t = 2$ seconds, find its

(i) angular velocity ω

(ii) angular acceleration α

[4 marks]

(d) A boy stands at the centre of a turn table with his two arms stretched. The turn table is set rotating with an angular speed of 40 r.p.m. How much is the angular speed of the boy if he folds his hands back and thereby reduces his moment of inertia to 2/5 times the initial value? Assume the turn table to rotate without friction. [2 marks]

(e) Consider a solid disc of radius r and mass m initially at rest on an inclined surface. Show that if the disc rolls without slipping from a height h, it reaches the bottom of the incline with speed

$$v = \sqrt{\frac{4gh}{3}}$$

[4 marks]

QUESTION SEVEN

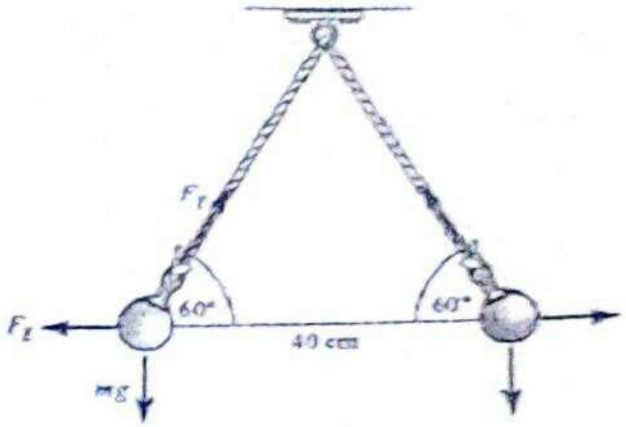
(a) In a Bohr model of the hydrogen atom, an electron charge (charge -e) circles a proton (charge +e) in an orbit of radius $r = 5.3\times10^{-11}$ m. The attraction of the proton for the electron furnishes the centripetal force needed to hold the electron in a circular orbit. Find

(i) the force of electrical attraction between the two particles, and

(ii) the electron's orbital speed. [5 marks]

(b) As shown in the Figure below, two identical balls, each of mass 0.10 g, carry identical charges and are suspended from a common point by two threads of equal length. At equilibrium

they position themselves as shown. Find the charge on each ball. [5 marks]



(d) Derive a relation between the electrical current I and the drift velocity v_d of the charge carriers. [5 marks]

(e) It is desired to make a wire that has a resistance of 8.0 Ω from 5.0 cm^3 of metal that has a resistivity of 9.0×10^{-8} Ω m. What should the length and cross-sectional area of the wire be? [5 marks]

Bonne chance