

The University of Fiji
(An Entity of Arya Pratinidhi Sabha of Fiji)



SCHOOL OF SCIENCE AND TECHNOLOGY

Semester 1, 2026

FINAL EXAMINATION PAPER

PHY101: Physics for Science and Engineering I

Important Instructions to Students:

1. Read the questions, instructions carefully and answer the questions. There are **13** pages in this paper.
2. You are allowed an **extra 10 minutes reading time** (during this time, you are not allowed to write with pen) and **180 minutes (3 Hours) to complete this paper**.
3. Silent, non-programmable calculators are allowed but not supplied.
4. Write all your answers in the answer booklet provided. If you need extra sheets, please ask from the supervisor. Write your name, course code and student identification number in the answer booklet and in the attendance sheet.
5. This paper contains **twelve (12) questions**, answer any **ten (10)** questions.
6. Write all your answers legibly. Ensure that all question numbers are properly written before the answer. The marker has the right to award zero for answers that are not legible.
7. This is a **Closed Book Examination**. The University views plagiarism, cheating and dishonest practice as serious offences and if found, offenders are penalized.

Examination Paper Content (Format):

<u>Questions</u>	<u>Content</u>	<u>Marks</u>	<u>Suggested Time</u>
1 -12	Analytic Problem-Solving Question	100 marks	180 Minutes
	TOTAL	100	180 Minutes

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Registration Certificate Number (RGN0020/11)*

CONSTANTS & DATA

Acceleration due to gravity, $g = 9.8 \text{ m s}^{-2}$
 Universal gravitational constant, $G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
 Avogadro number, $N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
 Boltzmann's constant, $k_B = 1.38 \times 10^{-23} \text{ J K}^{-1}$
 Universal gas constant, $R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$
 Mass of the Earth, $M_E = 5.98 \times 10^{24} \text{ kg}$
 Mass of Moon, $M_M = 7.36 \times 10^{22} \text{ kg}$
 Radius of the Earth, $R_E = 6.38 \times 10^6 \text{ m}$
 Latent heat of fusion of water, $L_f = 3.33 \times 10^5 \text{ J kg}^{-1}$
 Latent heat of vaporization of water, $L_v = 2.26 \times 10^6 \text{ J kg}^{-1}$
 Specific heat capacity of water, $C_w = 4186 \text{ J kg}^{-1} \text{ }^\circ\text{C}^{-1}$
 Stefan-Boltzmann constant, $\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$

Selected formulas:

$v_f = v_i + at$	$v_f^2 = v_i^2 + 2a\Delta x$	$\Delta x = v_i t + \frac{1}{2}at^2$
$\Delta x = \left(\frac{v_f + v_i}{t}\right)$	$f_s = \mu_s F_N$	$F_s = -kx$
$KE = \frac{1}{2}mv^2$	$PE_g = mgh$	$PE_s = \frac{1}{2}kx^2$
$p = mv$	$F = \frac{\Delta p}{t}$	$\omega_f = \omega_i + at$
$\omega_f^2 = \omega_i^2 + 2\alpha\theta$	$\theta = \omega_i t + \frac{1}{2}at^2$	$KE_{rot} = \frac{1}{2}I\omega^2$
$Q = mc\Delta t$	$\Delta L = \alpha L_i \Delta T$	$\Delta A = 2\alpha A_i \Delta T$
$\Delta V = \beta V_i \Delta T$	$WD = P\Delta V$	$Q_{gained} = Q_{lost}$
$P_{con} = kA \frac{(T_h - T_c)}{L}$	$P_{rad} = Ae\sigma T^4$	$PV = nRT$
$v = f\lambda$	$k = \frac{2\pi}{\lambda}$	$\omega = 2\pi f$

There are twelve (12) questions in this paper, Answer any ten (10) questions. Each question is worth ten marks. Start each question on a new page.

Question 1: 10 marks

1. Suppose the drag force F acting on a spherical object moving through a fluid depends on the density of the fluid ρ , the velocity v , and the radius r of the sphere.

$$F = k\rho^a v^b r^c$$

Using dimensional analysis, determine the unknown exponents a , b and c in the formula for F above, where k is a dimensionless constant. Write down the formula for F , using the values of the exponents determined.

(5 marks)

2. A laboratory technician is investigating the physical properties of a solid metal sphere. The radius of the sphere is measured and found to be (4.80 ± 0.01) cm, while its mass is measured using an electronic balance and found to be (0.95 ± 0.001) kg.

Calculate the density of the sphere in kg/m^3 and determine the associated uncertainty in the density calculation.

(5 marks)

Question 2: 10 marks

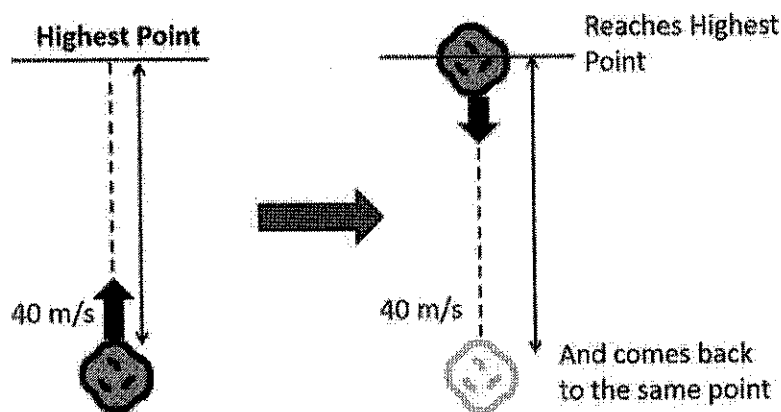
1. A bus is travelling along a straight road and enters a bus stop with an initial speed of 40 km/hr. At the instant it enters the bus stop, the driver applies the brakes, causing the bus to decelerate uniformly at -0.8 m/s^2 until it comes to rest. The bus stop platform is 80 m long.

(a) Calculate the time it would take the bus to stop. (2 marks)

(b) Determine the distance travelled by the bus before it comes to rest and state whether the bus stops within the platform, giving a clear justification of your answer.

(2 marks)

2. A rock is thrown vertically upward with an initial velocity of 40 m/s as shown in the figure below. It rises until it momentarily comes to rest at its maximum height before falling down. Calculate the time taken by the rock to reach the maximum height. (2 marks)



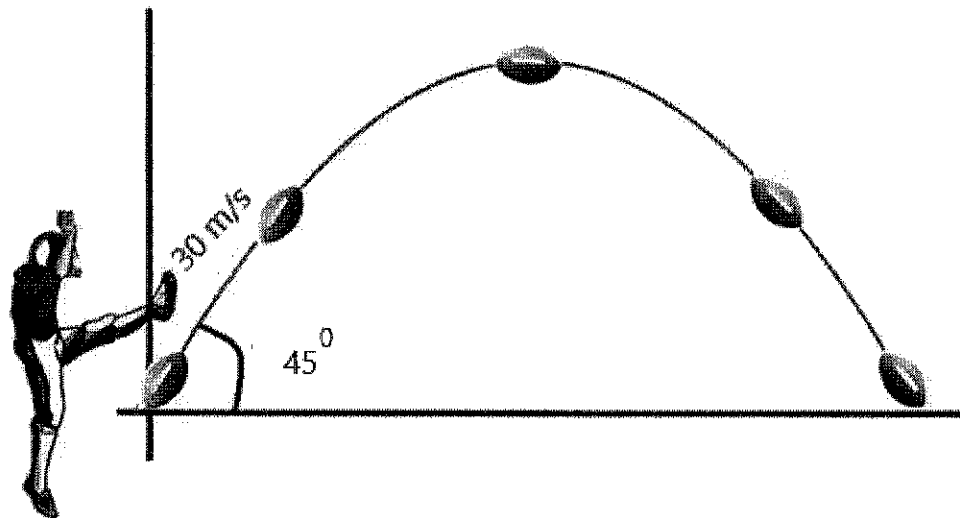
3. A car is travelling at a constant speed of 12 m/s when it passes a stationary police officer. At the instant the car passes the officer, the driver begins to accelerate uniformly at 1.5 m/s^2 . Simultaneously, the police officer starts from rest and accelerates uniformly at 3.0 m/s^2 in pursuit of the car.

Determine the time taken for the police officer to catch the car.

(4 marks)

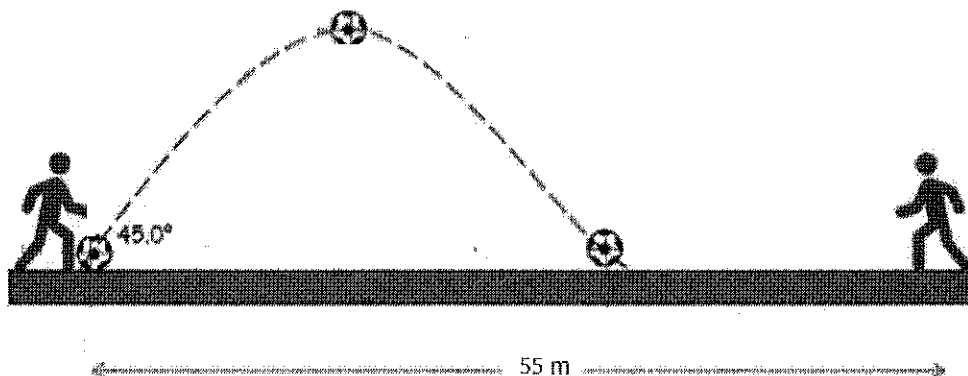
Question 3: 10 marks

1. A rugby ball is kicked so that it leaves the ground with an initial speed of 30 m/s at an initial angle 45° as shown in the figure below.



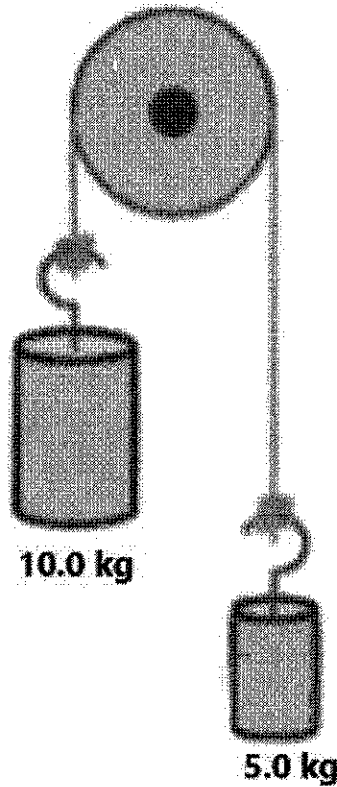
- (a) Find the magnitude and direction of its velocity, when $t = 2\text{ s}$. (3 marks)
- (b) Find the horizontal range, R . (3 marks)

2. A soccer ball is kicked from the ground with an initial speed of 19.5 m/s at an upward angle of 45.0° as shown in the figure below. A player 55 m away in the direction of the kick starts running to meet the ball as soon as it is kicked. What must be his average speed if he is to meet the ball just before it hits the ground? (4 marks)



Question 4: 10 marks

1. A 5.0 kg and 10.0 kg mass are attached by a string that is stretched around a pulley as shown in the figure below.



For the system shown, determine the:

- (a) Acceleration of the 10 kg mass. (3 marks)
- (b) Find the tension in the string connecting the two masses. (3 marks)

2. A 5.0 kg block is pulled along a horizontal rough surface by a constant force of 30 N acting at an angle of 30° above the horizontal. The coefficient of kinetic friction between the block and the surface is 0.20.

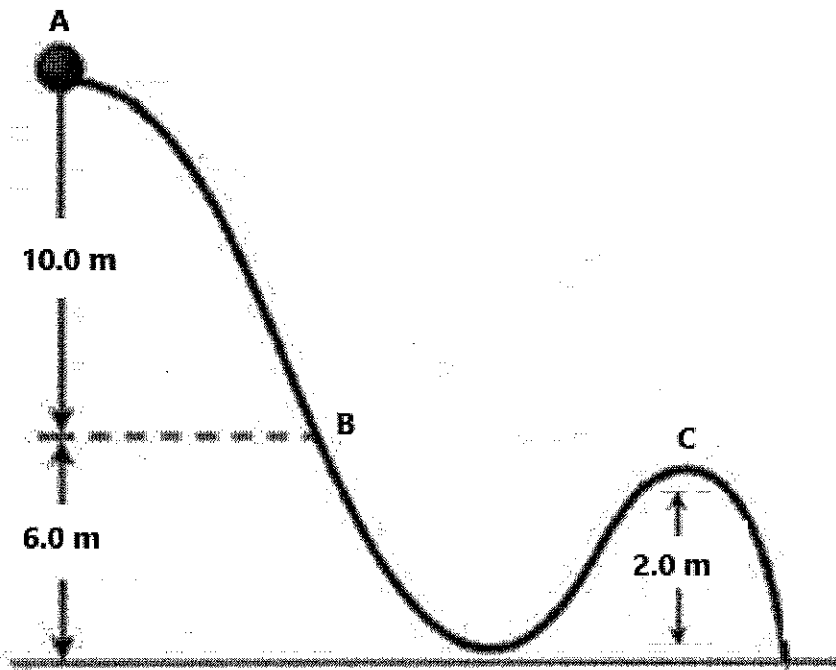
Calculate:

- (a) the normal reaction force acting on the block (2 marks)
- (b) the frictional force acting on the block (2 mark)

Question 5: 10 marks

1. A bead of mass 5 kg is released from rest from point *A* on a frictionless track as shown in the figure below. The track dips down and then rises again. Point *B* is at a height of 6 m, and point *C* is at a height of 2 m.

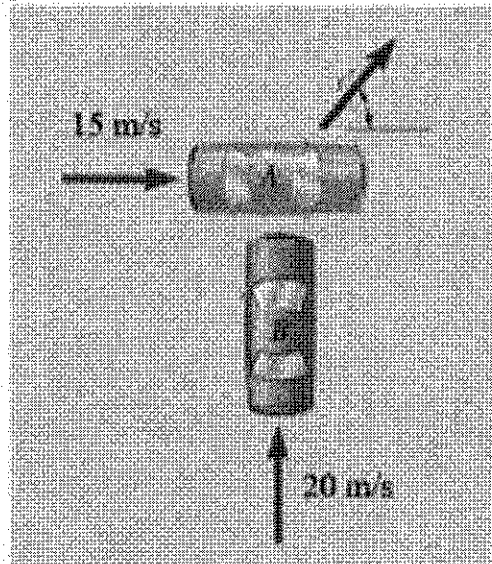
- (a) What is the gravitational potential energy of the bead at point *A*? (1 mark)
- (b) What is the bead's speed at point *B*? (2 marks)
- (c) What is the bead's speed at point *C*? (1 mark)



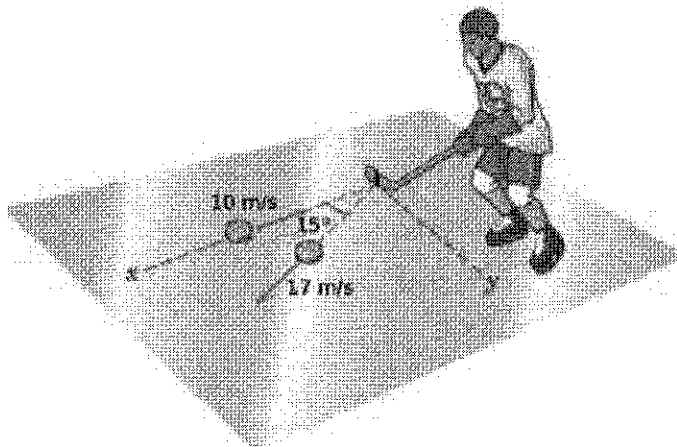
2. A spring is compressed from its natural length by 0.10 m. The spring constant is 200 N/m.
- (a) Calculate the force required to compress the spring to this displacement. (3 marks)
 - (b) Determine the elastic potential energy stored in the spring when it is compressed by 0.10 m. (3 marks)

Question 6: 10 marks

1. A 1200 kg car moving east at 15 m/s collides at a right angle with a 1500 kg car moving north at 20 m/s as illustrated in the figure below. The vehicles stick together after the collision. Find the final velocity of the two cars. (5 marks)



2. A ice-hockey puck with a mass of 0.2 kg has a velocity of 10 m/s before being struck by the hockey stick as illustrated in the figure below. After the impact the puck moves at 17 m/s at an angle of 15° with respect to the original direction. If the stick is in contact with the puck for 0.06 s, compute the average force exerted by the stick on the puck during contact. (5 marks)



Question 7: 10 marks

1. A bicycle wheel of radius 0.35 m is rotating at an initial angular velocity of 8.0 rad/s. A brake is applied, producing a constant angular deceleration of 2.0 rad/s² until the wheel comes to rest.

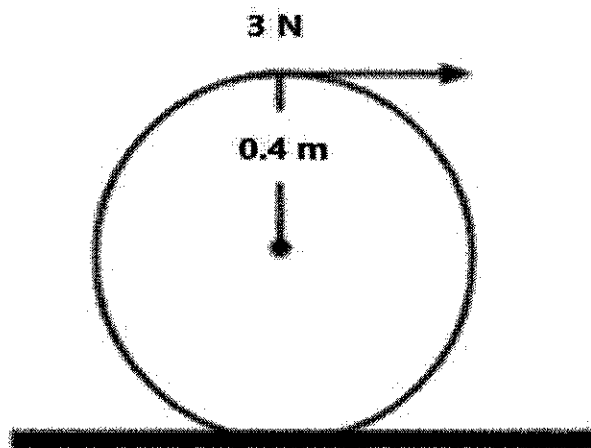
(a) Calculate the time taken for the wheel to stop rotating. (3 marks)

(b) Determine the total angular displacement of the wheel before it stops. (3 marks)

2. A solid disk of mass 2.5 kg and radius 0.4 m is mounted on a frictionless axle through its centre. A constant tangential force of 3 N is applied at the rim of the disk, causing it to start rotating from rest as illustrated in the figure below.

Assume the moment of inertia of a solid disk is:

$$I = \frac{1}{2}MR^2.$$



Calculate the angular acceleration of the disk.

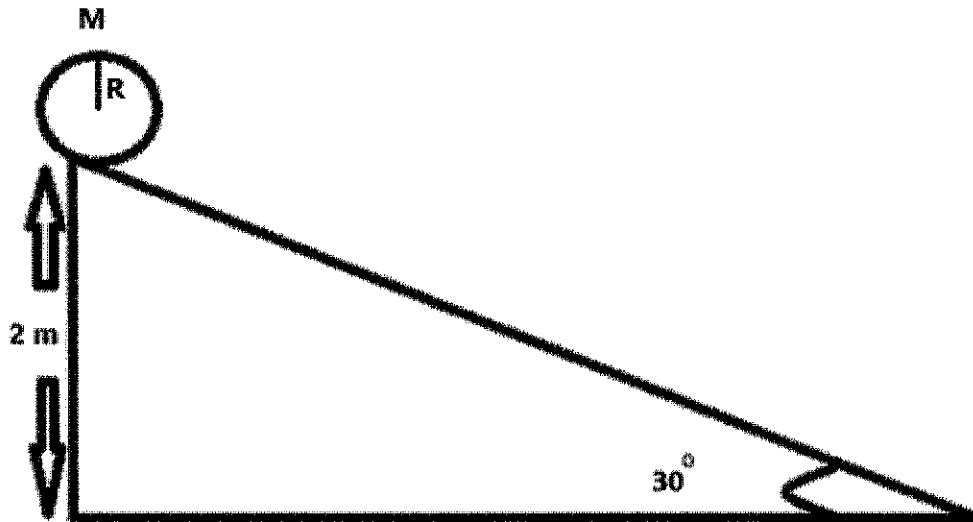
(4 marks)

Question 8: 10 marks

1. A ball of mass M and radius R starts from rest at a height of 2 m and rolls down a 30° slope, as shown in the diagram below. What is the linear speed of the ball when it leaves the incline?

(3 marks)

Assume that the ball rolls without slipping.



2. A 0.030 kg bullet is fired vertically upward at a speed of 200 m/s into a 0.15 kg baseball that is initially at rest. The bullet embeds itself in the baseball and they move together after the collision.

(a) Using the principle of conservation of momentum, determine the speed of the combined system immediately after the collision. (3 marks)

(b) Using the principle of conservation of mechanical energy, determine the maximum height reached by the combined system after the collision. (3 marks)

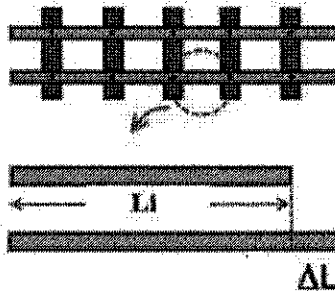
(c) State one assumption made in solving this problem and explain how it affects the result. (1 mark)

Question 9: 10 marks

1. A steel railway track has a length of 50.0 m at a temperature of 20°C as shown in the diagram below. The track is exposed to direct sunlight and its temperature rises to 45°C.

The coefficient of linear expansion of steel is $11 \times 10^{-6} \text{ }^{\circ}\text{C}^{-1}$.

- (a) Calculate the increase in length of the railway track. (3 marks)
- (b) Determine the final length of the track at 45°C. (2 marks)
- (c) Explain why small gaps are left between railway tracks during installation. (1 mark)



2. A 0.150 kg copper block, initially at 25.0°C, is placed into 0.300 kg of water at 80.0°C contained in an insulated container. The system is allowed to reach thermal equilibrium.

Assume:

- Specific heat capacity of copper = $385 \text{ J kg}^{-1} \text{ }^{\circ}\text{C}^{-1}$
- Specific heat capacity of water = $4200 \text{ J kg}^{-1} \text{ }^{\circ}\text{C}^{-1}$

- (a) Write the heat transfer equation for the system at equilibrium. (1 mark)
- (b) Determine the final equilibrium temperature of the system. (3 marks)

Question 10: 10 marks

1. A sinusoidal wave on a stretched string is described by the wave function:

$$y = 0.20 \sin(0.5x - 25t)$$

where x and y are in metres and t is in seconds.

- (a) Determine the amplitude, angular wave number, angular frequency, wavelength, and wave speed of the wave. (5 marks)
- (b) State the direction in which the wave is travelling. (1 mark)
- (c) Write expressions for the transverse velocity and transverse acceleration of the particles of the string. (4 marks)

Question 11: 10 marks

1. Using *Newton's Second Law of Motion*, describe the relationship between force, mass, and acceleration.

Explain how changing mass affects acceleration when force is constant. (2 marks)

2. Describe the three modes of heat transfer:

- conduction
- convection
- radiation

For each mode of heat transfer, briefly explain the mechanism involved and provide one relevant real-life example where it occurs. (4.5 marks)

3. If pressure and volume are known at each step then a *PV diagram* can be plotted. This allows us to visualize the process through which the gas is progressing. Which quantity is represented by the area under a PV diagram? (1 mark)

4. The Hooke's law is given by the following equation:

$$F_s = -kx$$

(a) Explain the significance of the negative sign in this formula. (2 marks)

(b) What is the energy stored in springs known as? (0.5 marks)

Question 12: 10 marks

1. Distinguish between conservative and non-conservative forces, and explain how each type influences the conservation of mechanical energy. (3 marks)

2. Using the First Law of Thermodynamics, answer the following questions:

(a) Explain why heat (Q) and work (W) are considered path-dependent quantities, while internal energy (ΔU) is path-independent. (3 marks)

(b) A gas undergoes a cyclic process. Explain what is meant by a cyclic process and state the value of the change in internal energy over one complete cycle. (2 marks)

3. Distinguish between mechanical waves and electromagnetic waves, giving one example of each. (2 marks)

THE END