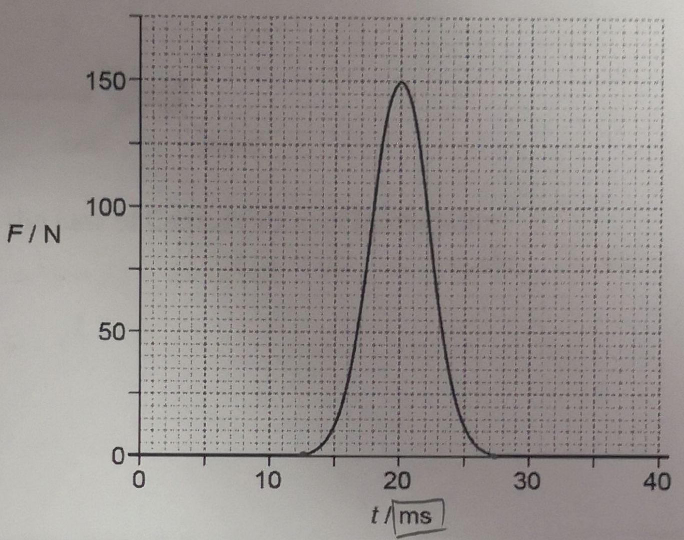
Part B: Numeric and Short Answer [35 marks]

FULL solutions are required for numeric problems (Givens/Required to Find or a labelled diagram, equation, substitution, final answer, statement with correct significant digits, units and direction if a vector quantity.

Short Answer must be written in complete sentences. (Just stating points from a marking scheme will not guarantee full marks).

Question 1 The graph shows the variation with time *t* of the horizontal force *F* exerted on a tennis ball by a racket.



The tennis ball was stationary at the instant when it was hit. The mass of the tennis ball is 5.8×10^{-2} kg. The area under the curve is 0.84 N s.

1a. *[3 marks]* Calculate the speed of the ball as it leaves the racket.

Δp = area under F-t graph = 0.84 Ns

$m = 5.8 \times 10^{-2}$ kg

$v = ?$

$u = 0$, stationary

$\Delta p = m_1 v_1 - mu$

$0.84\text{ Ns} = 5.8 \times 10^{-2}\text{ kg}(v) - \cancel{(5.8 \times 10^{-2}\text{ kg})(0)} \rightarrow 0$

$\dfrac{0.84\text{ kgms}^{-1}\text{s}}{5.8 \times 10^{-2}\text{ kg}} = v$

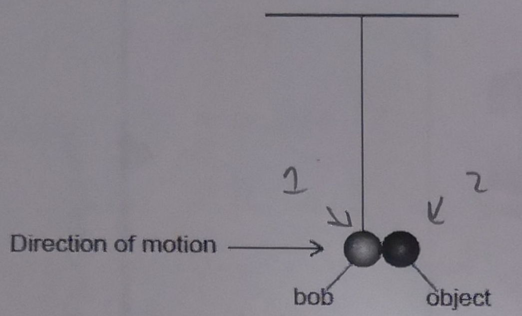
$14.4827586\ldots\text{ ms}^{-1} = v$

$14\text{ ms}^{-1} = v$

∴ the speed of the ball as it leaves the raquet is 14 ms⁻¹.

Question 2 A small metal pendulum bob of mass 75 g is suspended at rest from a fixed point with a length of thread of negligible mass. Air resistance is negligible. The bob is then displaced to the left.

At time $t = 0$ the bob is moving horizontally to the right at $0.8\ \text{m s}^{-1}$. It collides with a small stationary object ~~also~~ of mass 150 g. Both objects then move together with motion that is simple harmonic.



2a. *[2 marks]* State the Law of Conservation of Momentum.

Momentum is always constant in a system unless an external force acts on it.

2b. *[3 mark]* Calculate the speed of the combined masses immediately after the collision.

no need to convert since will cancel

$m_1 = 75g$

$m_2 = 150g$

$u_1 = 0.8 ms^{-1}$

$u_2 = 0$

$v = ?$

15.0

Conservation of momentum

$m_1 u_1 + m_2 u_2 = (m_1 + m_2) v$

$(75g)(0.8 ms^{-1}) + \cancel{(150g)(0)}^{0} = (75g + 150g) v$

$v = \frac{(75g)(0.8 ms^{-1})}{(75g + 150g)}$

$v = 0.26666\ldots ms^{-1}$

∴ the speed of the combined masses immediately after the collision is $0.3 ms^{-1}$.

2c. *[3 marks]* Show that the collision is inelastic.

$m_1 = 75g = 75 \times 10^{-3} kg$
$u_1 = 0.8 ms^{-1}$
$m_2 = 150g = 150 \times 10^{-3} kg$
$u_2 = 0$
$v = 0.26666... ms^{-1}$ $(\frac{4}{15})$

$\Delta E_K = E_{K \text{ total after}} - E_{K \text{ total before}}$

$= (\frac{1}{2}(m_1 + m_2) v^2) - (\frac{1}{2} m_1 u_1^2 + \frac{1}{2} m_2 u_2^2)$

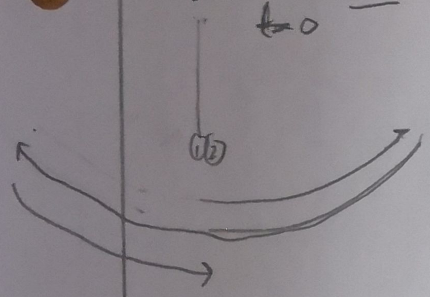
$= (\frac{1}{2}(75 \times 10^{-3} kg + 150 \times 10^{-3} kg)(0.26666... ms^{-1})^2) - (\frac{1}{2}(75 \times 10^{-3} kg)(0.8 ms^{-1})^2 + \cancel{\frac{1}{2}(150 \times 10^{-3} kg)(0)^2})$ 0

$= 0.008 J - 0.024 J$

$\Delta E_K = -0.016$

The negative in the change in energy represents a decrease in kinetic energy resulting in the objects to stick together and thus the collision is inelastic.

2d. *[2 marks]* Describe the changes in gravitational potential energy of the oscillating system from $t = 0$ as it oscillates through one cycle of its motion.



Right after the collision, the GPE of the system is at the lowest. As it moves to the right, GPE increases until it reaches it max value when it oscillates to the furthest right. It then oscillates back to the lowest position with minimum GPE. This repeats when the system oscillates to the left, finishing the 2nd half of the cycle.