Engineering Mechanics
IAT-2 Solution → Marking

1a

$$V_c = IC \times \omega$$

$$\therefore \omega = \frac{10}{0.75} = 13.3 \ r/s \quad -\tfrac{1}{2}M$$

$$V_p = IP \times \omega = 1.06 \times 13.3$$
$$= 14.13 \ m/s \quad -\tfrac{1}{2}M$$

$$V_Q = IQ \times \omega = 1.5 \times 13.3 = 19.95 \ \tfrac{m}{s} \quad -\tfrac{1}{2}M$$

1b

$$IA = \sqrt{26^2 - 10^2} = 24M \quad -1M$$

1c
$$S = t^3 - 3t^2 + 2t + 5$$
$$V = \frac{dS}{dt} = 3t^2 - 6t + 2 \quad -\tfrac{1}{2}M$$
$$a = \frac{dV}{dt} = 6t - 6 \quad -\tfrac{1}{2}M$$
$$at \ t = 4S \quad V = 26 m/s \quad -\tfrac{1}{2}M$$
$$a = 18 \ m/s^2 \quad -\tfrac{1}{2}M$$

1d) The Limiting frictional force Fmax is directly proportional to normal reaction (Fmax ∝ N) — $\tfrac{1}{2}$M

2) Frictional force is independent of the area of contact between the two surfaces. — $\tfrac{1}{2}$M

3) Frictional force is dependent on the roughness of contact between the two surfaces — $\tfrac{1}{2}$M

4) The frictional force is always tangential to the contact surface and acts in a direction opposite to that in which the body tends to move — $\tfrac{1}{2}$M

1e) $Y = \frac{x^2}{20}$, $\frac{dy}{dx} = 0.1x$, $\frac{d^2y}{dx^2} = 0.1$ — $\tfrac{1}{2}$M

$\frac{dy}{dx}$ at $x=10 = 1$, $\frac{d^2y}{dx^2}$ at $x=10, 0.1$ — $\tfrac{1}{2}$M

$$\rho = \frac{\left[1 + \left(\frac{dy}{dx}\right)^2\right]^{3/2}}{d^2y/dx^2} = \frac{(1 + 1)^{3/2}}{0.1} = 28.28m \quad -1M$$

1f)

(OR) Angle of repose ∠

down Wt force = 101.6N — $\tfrac{1}{2}$M

UP Fmax = 151.6 N — $\tfrac{1}{2}$M

$\therefore$ Block is at rest — $\tfrac{1}{2}$M

$Tan(\phi)$
$= Tan(0.4) = 21.$
$= 21.8° - 1M$

$\therefore$ Block is at rest — 1M

2a
$$V_0 = 2 \ m/S$$

Area under a-t = change in 'V'
$$V_4 - V_0 = \tfrac{1}{2} \times 4 \times 2 = 4 \ m/s$$
$$\therefore V_4 = 4 + 2 = 6 \ m/s \quad -\tfrac{1}{2}M$$
$$V_8 - V_4 = \tfrac{1}{2} \times 4 \times 5 = 10$$
$$\therefore V_8 = 10 + 6 = 16 \ m/s \quad -\tfrac{1}{2}M$$
$$V_{10} - V_8 = 2 \times 5 = 10$$
$$\therefore V_{10} = 26 \ m/S \quad -\tfrac{1}{2}M$$

Area under V-t = change in S
$$S_4 - S_0 = 2 \times 4 + \tfrac{2}{3} \times 4 \times 4 = 18.67m$$
$$\therefore S_4 = 18.67m \quad -\tfrac{1}{2}M$$
$$S_8 - S_4 = 4 \times 6 + \tfrac{1}{3} \times 4 \times 10$$
$$\therefore S_8 = 56m \quad -\tfrac{1}{2}M$$
$$S_{10} - S_8 = 2 \times 16 + \tfrac{1}{2} \times 2 \times 10$$
$$\therefore S_{10} = 42 + 56 = 98m \quad -\tfrac{1}{2}M$$

(2b) $\Sigma F_x = 0 \quad N_B = \mu N_A \quad —① — \frac{1}{2}M$

$\Sigma F_y = 0 \quad N_A = W \quad —② — \frac{1}{2}M$

$\Sigma M_A = 0 \quad N_B \times 7 \underset{Sin}{\cancel{\subset}} 68 = W \times 3.5 \cos 68 \;\; —2M$

$\mu N_A \times 7 \sin 68 = N_A \times 3.5 \cos 68 \;\; — \frac{1}{2}M$

$\therefore \mu = \dfrac{3.5 \cos 68}{7 \sin 68}$

$\mu = 0.202 — \frac{1}{2}M$
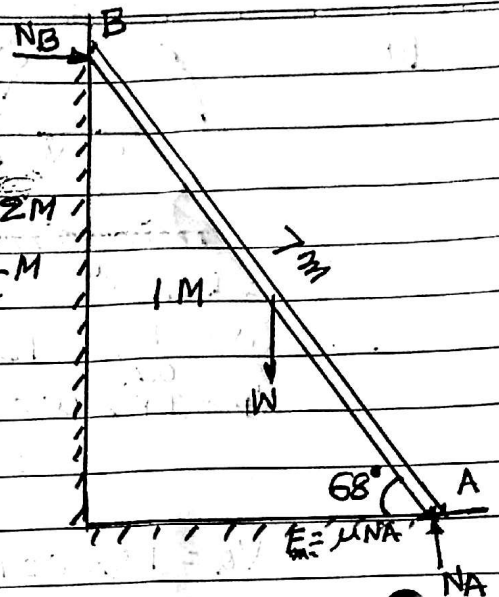
3a. In $\triangle IBD$, by Sine rule

$\dfrac{0.4}{\sin 45°} = \dfrac{IB}{\sin 45°} = \dfrac{ID}{\sin 90°}$

$IB = 0.4m — \frac{1}{2}M \quad ID = 0.5657m — \frac{1}{2}M$

$V_D = ID \times \omega_{BD} \quad — \frac{1}{2}M$

$\therefore \omega_{BD} = \dfrac{3}{0.5657} = 5.303 \; \text{m/s} \circlearrowleft — \frac{1}{2}M$

$V_B = IB \times \omega_{BD} = 0.4 \times 5.303$

$\therefore V_B = 2.121 \; m/s \; \angle 45° \; — 1M$

$V_B = AB \times \omega_{AB}$

$\therefore \omega_{AB} = \dfrac{2.121}{0.4} = 5.303 \; rad/s \; — 1M$
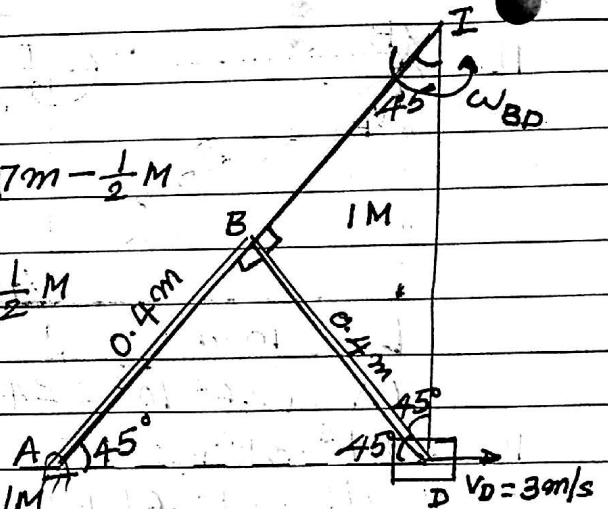
3b i) Total time taken to reach point B $— \frac{1}{2}M$

$S_y = U_y t + \frac{1}{2} g t^2$

$-50 = 20 \sin(30) \times t + \frac{1}{2}(-9.81) \times t^2 \; — \frac{1}{2}M$

$4.9t^2 - 10t - 50 = 0 \quad — \frac{1}{2}M$

$\therefore t = 4.37 \; sec. \quad — \frac{1}{2}M$

ii) Velocity with which it strikes at B.

$V_x = U \cos\alpha = 20 \cos 30 = 17.32 \; m/s — \frac{1}{2}M$

$V_y = U_y - gt = 10 - 9.81 \times 4.37 — 1M$

$\qquad = -32.873 \; m/s = 32.87 \; m/s \downarrow — \frac{1}{2}M$

$V_B = \sqrt{(V_x)^2 + (V_y)^2} = 37.15 \; m/s — \frac{1}{2}M$

$\beta = \tan^{-1}\left(\dfrac{V_y}{V_x}\right) = 62.2° — \frac{1}{2}M$