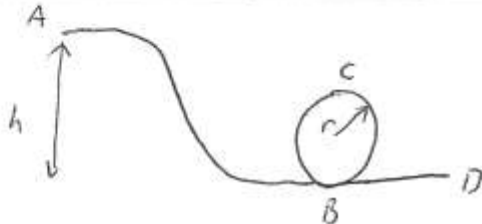
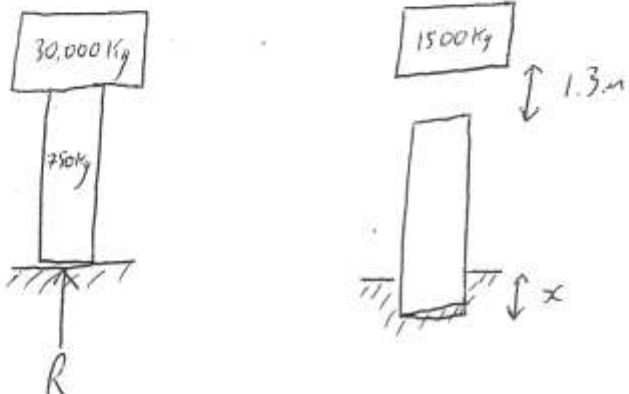




## EXAMINATION SOLUTIONS: SESSION 2010/2011

|              |                                       |       |         |
|--------------|---------------------------------------|-------|---------|
| School:      | LOGISTICS & MANUFACTURING ENGINEERING |       |         |
| Programme:   |                                       | Year: | 2       |
| Module/Unit: | STRESS ANALYSIS & DYNAMICS            |       |         |
| Author:      | KEVIN LAKE                            | Page: | 1 of 15 |

| Question No | Question                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Marks |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| ①<br>a<br>i |  <p> <math>A \rightarrow C</math> : LOSS OF P.E. = GAIN IN K.E.<br/> <math>mg(h - 2r) = \frac{1}{2}mv^2</math><br/> <math>\therefore v^2 = 2g(h - 2r) *</math> </p> <p>FOR THE CAR TO REMAIN IN <del>CONTACT</del> CONTACT THE UPWARD CENTRIFUGAL FORCE MUST BE GREATER OR EQUAL TO THE WEIGHT</p> $\therefore \frac{mv^2}{r} \geq mg$ <p> <math>\therefore</math> FROM <math>*</math> <math>\frac{2mg(h - 2r)}{r} \geq mg</math><br/> <math>2(h - 2r) \geq r</math><br/> <math>2h - 4r \geq r</math><br/> <math>2h \geq 5r \quad \therefore \underline{\underline{h \geq 2.5r}}</math> </p> | ⑤     |

| Question No | Question                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Marks |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| (ii)        | <p>ASSUMPTIONS INCLUDE THAT ALL P.E. IS CONVERTED TO K.E. AT C, NEGLECTING ROLLING RESISTANCE &amp; <del>ROBUST</del> WIND RESISTANCE. ALSO ZERO ENERGY IS LOST DUE TO NOISE AND DEFORMATION OF THE WHEELS/TRACKS ETC</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | (2)   |
| (b)(i)      |  <p>The diagram consists of two parts. On the left, a rectangular block labeled '30,000 kg' sits on top of a vertical rectangular support labeled '750 kg'. The support is on a horizontal ground line with diagonal hatching below it. An upward arrow from the ground is labeled 'R'. On the right, a rectangular block labeled '1500 kg' is shown above a vertical rectangular support. A double-headed vertical arrow between the block and the support is labeled '1.3 m'. The support is on a horizontal ground line with diagonal hatching below it. A downward arrow from the support is labeled 'x'.</p> <p>• GROUND RESISTANCE : <math>R = mg</math><br/> <math>= (750 + 30,000) \times 9.81</math><br/> <math>= \underline{\underline{301.7 \times 10^3 \text{ N}}}</math></p> <p>• VELOCITY OF IMPACT :<br/> <math>v^2 = u^2 + 2as</math><br/> <math>v = \sqrt{u^2 + 2as}</math><br/> <math>= \sqrt{0^2 + 2 \times 9.81 \times 1.3}</math><br/> <math>= \underline{\underline{5.05 \text{ ms}^{-1}}}</math></p> | (1)   |

## Continuation Sheet

|              |                            |       |         |
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| Module/Unit: | STRESS ANALYSIS & DYNAMICS | Page: | 3 of 15 |
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| Question No | Question                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Marks                                       |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|
|             | <p>• MOMENTUM OF HAMMER BEFORE IMPACT = MOMENTUM OF HAMMER + PILE AFTER IMPACT</p> $m_1 V_1 = m_2 V_2$ $1500 \times 5.05 = (1500 + 750) \times V$ $\therefore V = \underline{\underline{3.37 \text{ ms}^{-1}}}$ <p>• INITIAL K.E JUST AFTER IMPACT = <math>\frac{1}{2} m V^2</math></p> $= \frac{1}{2} \times (750 + 1500) \times 3.37^2$ $= \underline{\underline{12776.5 \text{ J}}}$ <p>• CHANGE IN P.E AFTER IMPACT = <math>\Delta mgh</math></p> $= -(1500 + 750) \times 9.81 \times$ $= \underline{\underline{-22072.5 \text{ x J}}}$ <p><math>\therefore</math> TOTAL WORK DONE = <math>12776.5 - (-22072.5 \text{ x})</math></p> <p>NOW WORK DONE = <math>Fd</math></p> $\therefore d = \frac{\text{WORK DONE}}{F}$ $\therefore x = \frac{12776.5 + 22072.5 \text{ x}}{301.7 \times 10^3}$ $301.7 \times 10^3 \text{ x} - 22072.5 \text{ x} = 12776.5$ $\therefore x = 0.046 = \underline{\underline{46 \text{ mm}}}$ | <p>(2)</p> <p>(1)</p> <p>(1)</p> <p>(2)</p> |

# Continuation Sheet

|              |                            |       |         |
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| Module/Unit: | STRESS ANALYSIS & DYNAMICS | Page: | 4 of 15 |
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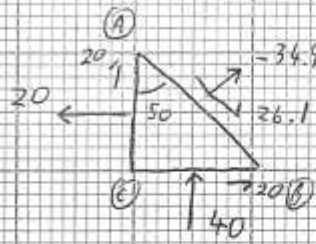
| Question No | Question                                                                                                                                                                                                                    | Marks |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| (ii)        | <p>ENERGY LOSS = A.P.E. OF HAMMER - WORK DONE</p> $= 1500 \times 9.81 \times (1.3 + 0.046) - 301.7 \times 10^3 \times 0.046$ $= 19806 - 13878$ $= \underline{\underline{5928 \text{ J}}}$                                   | (2)   |
| (iii)       | <p>EFFICIENCY = <math>\frac{\text{WORK DONE AGAINST GROUND}}{\text{WORK DONE IN RABBIT HAMMER}}</math></p> $= \frac{301.7 \times 10^3 \times 0.046}{1500 \times 9.81 \times 1.3}$ $= 0.73$ $= \underline{\underline{73\%}}$ | (1)   |
| (iv)        | <ul style="list-style-type: none"> <li>• ENERGY TRANSFERRED TO SOUND ETC</li> <li>• THE HAMMER WOULD REBOUND</li> <li>• THE GROUND RESISTANCE IS LIKELY TO INCREASE AS THE GROUND GETS MORE COMPACT</li> </ul> <p>ETC</p>   | (2)   |
|             |                                                                                                                                                                                                                             | 20    |

## Continuation Sheet

| Module/Unit: | STRESS ANALYSIS & DYNAMICS                                                                                                             | Page: | 5 of 15 |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------|-------|---------|
| Question No. | Question                                                                                                                               | Marks |         |
|              |                                                                                                                                        |       |         |
| (2a)         |                                                                                                                                        |       |         |
|              | $\theta = 90 - 40 = 50^\circ$                                                                                                          | 1     |         |
|              | $\sigma_x = 20 \text{ MPa}$                                                                                                            |       |         |
|              | $\sigma_y = -40 \text{ MPa}$                                                                                                           |       |         |
|              | $\tau_{xy} = -20 \text{ MPa}$                                                                                                          |       |         |
|              |                                                                                                                                        |       |         |
|              | $\therefore \sigma_\theta = \frac{1}{2}(\sigma_x + \sigma_y) + \frac{1}{2}(\sigma_x - \sigma_y) \cos 2\theta + \tau_{xy} \sin 2\theta$ |       |         |
|              | $= \frac{1}{2}(20 - 40) + \frac{1}{2}(20 + 40) \cos 100 - 20 \sin 100$                                                                 |       |         |
|              | $= -34.9 \text{ MPa}$                                                                                                                  | 2     |         |
|              |                                                                                                                                        |       |         |
|              | $\tau_\theta = \frac{1}{2}(\sigma_x - \sigma_y) \sin 2\theta - \tau_{xy} \cos 2\theta$                                                 |       |         |
|              | $= \frac{1}{2}(20 + 40) \sin 100 + 20 \cos 100$                                                                                        |       |         |
|              | $= 26.1 \text{ MPa}$                                                                                                                   | 2     |         |
|              |                                                                                                                                        |       |         |
|              | $\sigma_1 = \frac{1}{2}[(\sigma_x + \sigma_y) + \sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}]$                                        |       |         |
|              | $= \frac{1}{2}[(20 - 40) + \sqrt{(20 + 40)^2 + 4(-20)^2}]$                                                                             |       |         |
|              | $= \frac{1}{2}(-20 + \sqrt{3600 + 1600})$                                                                                              |       |         |
|              | $= 26.06 \text{ MPa}$                                                                                                                  | 2     |         |

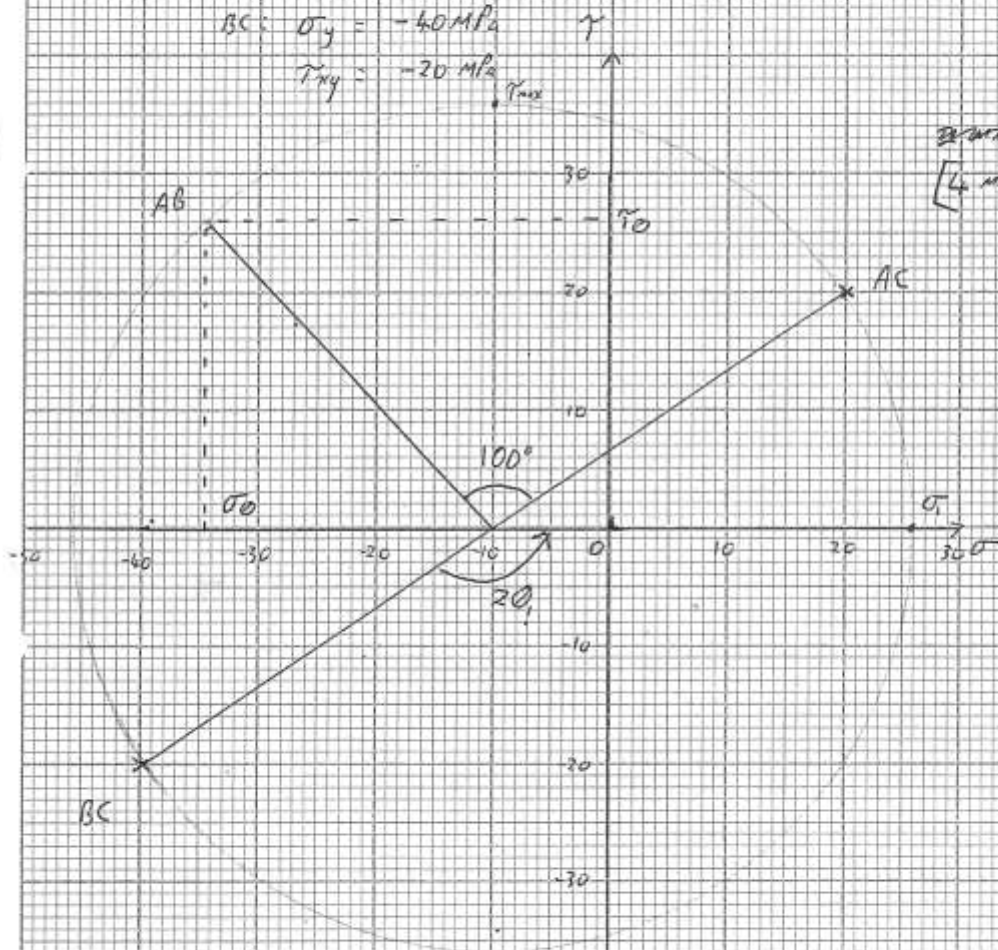
## Continuation Sheet

| Module/Unit: STRESS ANALYSIS & DYNAMICS |                                                                                                                                                                                                                                                                             | Page: 6 of 15 |
|-----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| Question No                             | Question                                                                                                                                                                                                                                                                    | Marks         |
| (20)                                    | $\tau_{max} = \frac{1}{2} \sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}$ $= \frac{1}{2} \sqrt{(20 + 40)^2 + 4(-20)^2}$ $= 36.06 \text{ MPa}$                                                                                                                                | 2             |
| (d)                                     | <p>SEE MOHR'S CIRCLE OVER PAGE.</p> <p>TAKING MEASUREMENTS: <math>\sigma_0 \approx -34.5 \text{ MPa}</math></p> <p><math>\tau_0 \approx 26 \text{ MPa}</math></p> <p><math>\sigma_1 \approx 26 \text{ MPa}</math></p> <p><math>\tau_{max} \approx 36 \text{ MPa}</math></p> | (4)           |
| (e)                                     | <p>BY MEASUREMENT <math>2\theta_1 \approx 146^\circ</math></p> <p><math>\therefore \theta_1 \approx 73^\circ</math></p>                                                                                                                                                     | 2             |
| (f)                                     | (d) IS APPROXIMATE AS THEY ARE MEASURED.                                                                                                                                                                                                                                    | 1             |
|                                         |                                                                                                                                                                                                                                                                             | 20            |



Plot: AC:  $\sigma_x = 20 \text{ MPa}$   
 $\tau_{xy} = 20 \text{ MPa}$

BC:  $\sigma_y = -40 \text{ MPa}$   
 $\tau_{xy} = -20 \text{ MPa}$



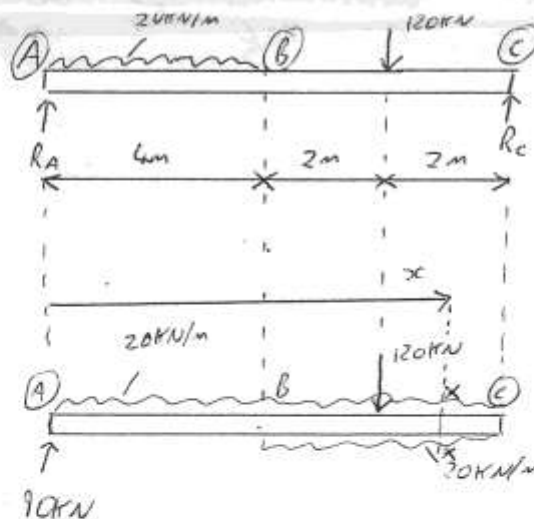
2 MARKS  
 [4 MARKS]

# Continuation Sheet

|              |                            |       |          |
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| Question No | Question | Marks |
|-------------|----------|-------|
|-------------|----------|-------|

4a



ACTUAL PROBLEM

INTEGRATING DUMMY U.D.L

FROM ACTUAL PROBLEM:

$$\begin{aligned} \sum M_C = 0 & \therefore 8R_A = 120 \times 2 + (20 \times 4) \times 6 \\ & = 720 \\ \therefore R_A & = 90 \text{ kN} \end{aligned}$$

2

1

# Continuation Sheet

|              |                            |       |         |
|--------------|----------------------------|-------|---------|
| Module/Unit: | STRESS ANALYSIS & DYNAMICS | Page: | 9 of 15 |
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| Question No  | Question                                                                                                                                                                                       | Marks |
|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| (4a)<br>CONT | $M_{max} = 90x - 20x \cdot \frac{x}{2} + 20(x-4) \frac{(x-4)}{2} - 120(x-6)$                                                                                                                   | ①     |
|              | $EI \frac{d^2 y}{dx^2} = 90x - \frac{20x^2}{2} + \frac{20(x-4)^2}{2} - 120(x-6)$                                                                                                               | ①     |
|              | $\frac{dy^2}{dx^2} = \frac{1}{EI} \left[ 90x - \frac{20x^2}{2} + \frac{20(x-4)^2}{2} - 120(x-6) \right]$                                                                                       | ①     |
|              | $\frac{dy}{dx} = \frac{1}{EI} \left[ \frac{90x^2}{2} - \frac{20x^3}{6} + \frac{20(x-4)^3}{6} - \frac{120(x-6)^2}{2} + A \right] \text{ (1)}$                                                   | ①     |
|              | $y = \frac{1}{EI} \left[ \frac{90x^3}{6} - \frac{20x^4}{24} + \frac{20(x-4)^4}{24} - \frac{120(x-6)^3}{6} + Ax + B \right] \text{ (2)}$                                                        | ①     |
|              | <p>BOUNDARY CONDITIONS : FROM (2) :</p> <p>WHEN <math>x=0</math> <math>y=0 \therefore B=0</math></p>                                                                                           | ①     |
|              | <p>WHEN <math>x=8</math> <math>y=0</math></p>                                                                                                                                                  | ①     |
|              | <p><math>\therefore</math> FROM (2) <math>0 = \frac{1}{EI} \left[ \frac{90 \cdot 8^3}{6} - \frac{20 \cdot 8^4}{24} + \frac{20 \cdot 4^4}{24} - \frac{120 \cdot 2^3}{6} + 8A \right]</math></p> | ①     |
|              | $= 7680 - 3413.3 + 213.3 - 160 + 8A$                                                                                                                                                           | ①     |
|              | $\therefore A = \underline{\underline{-540}}$                                                                                                                                                  | ①     |
|              | <p><math>\therefore</math> SLOPE :</p> $\frac{dy}{dx} = \frac{1}{EI} \left[ \frac{90x^2}{2} - \frac{20x^3}{6} + \frac{20(x-4)^3}{6} - \frac{120(x-6)^2}{2} - 540 \right] \text{ (3)}$          | ①     |
|              | <p>DEFLECTION</p> $y = \frac{1}{EI} \left[ \frac{90x^3}{6} - \frac{20x^4}{24} + \frac{20(x-4)^4}{24} - \frac{120(x-6)^3}{6} - 540x \right] \text{ (4)}$                                        | ①     |

# Continuation Sheet

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| Module/Unit: | STRESS ANALYSIS & DYNAMICS | Page: | 10 of 15 |
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| Question No  | Question                                                                                                                                                                                                                                                                                                                                                                 | Marks                      |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|
| (4a)<br>1047 | <p>SLOPE AT A (WHEN <math>x=0</math>)</p> $\frac{dy}{dx} = \frac{1}{EI} \left[ \frac{90x^3}{2} - \frac{20x^3}{6} + \frac{20(x-4)^3}{6} - \frac{120(x-6)^3}{2} - 540 \right]$ <p><math>\frac{dy}{dx} = \frac{-540}{EI}</math></p>                                                                                                                                         | <p>①</p> <p>①</p> <p>①</p> |
| (4b)         | <p>SLOPE AT C (WHEN <math>x=8</math>)</p> $\frac{dy}{dx} = \frac{1}{EI} \left[ \frac{90 \times 8^3}{2} - \frac{20 \times 8^3}{6} + \frac{20 \times 4^3}{6} - \frac{120 \times 2^3}{2} - 540 \right]$ $= \frac{1}{EI} [2880 - 1706.7 + 213.3 - 240 - 540]$ <p><math>\frac{dy}{dx} = \frac{606.6}{EI}</math></p>                                                           | <p>①</p> <p>①</p> <p>①</p> |
| (4c)         | <p>DEFLECTION AT B (WHEN <math>x=4</math>)</p> $y = \frac{1}{EI} \left[ \frac{90x^4}{6} - \frac{20x^4}{24} + \frac{20(x-4)^4}{24} - \frac{120(x-6)^4}{6} - 540x \right]$ $\therefore y = \frac{1}{EI} \left[ \frac{90 \times 4^4}{6} - \frac{20 \times 4^4}{24} - 540 \times 4 \right]$ $= \frac{1}{EI} [960 - 213.3 - 2160]$ <p><math>y = \frac{-1413.3}{EI}</math></p> | <p>①</p> <p>①</p> <p>①</p> |



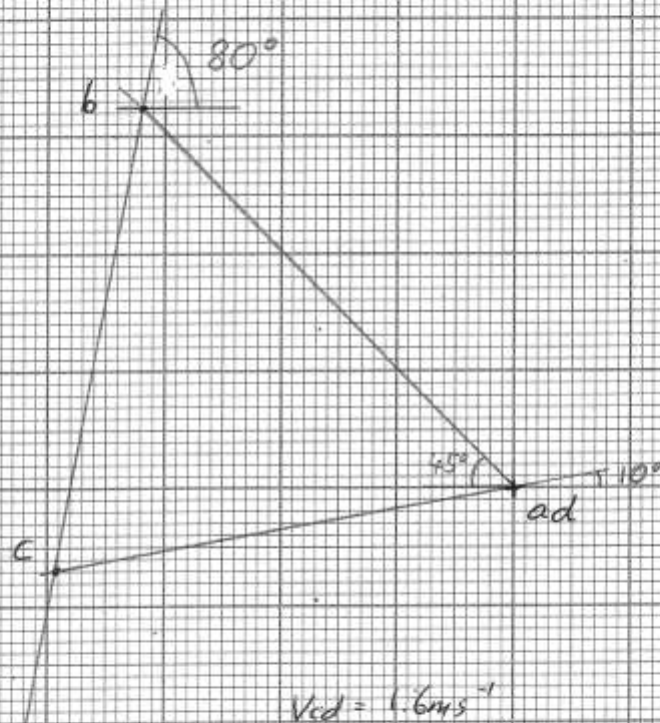
# EXAMINATION SOLUTIONS: SESSION 2010/2011

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|--------------|------------------------------------|-------|----------|
| School:      |                                    |       |          |
| Programme:   |                                    | Year: |          |
| Module/Unit: | STRESS ANALYSIS & DYNAMICS (CONT.) |       |          |
| Author:      |                                    | Page: | 11 of 15 |

| Question No | Question                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Marks                                                  |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|
| (4) (a)     | <p>POINTS A &amp; D DO NOT MOVE RELATIVE TO EACH OTHER SO ARE REPRESENTED BY THE SAME POINT <math>ad</math>.</p> <p>• THE VELOCITY OF <math>b</math> RELATIVE TO <math>a</math></p> $V_{ba} = \omega AB$ $= 70 \times \frac{2\pi}{60} \times 0.25 = 1.83 \text{ m/s}$ <p>THIS ACTS <u>PERP</u> TO THE LINK <math>AB</math>, i.e. AT <math>45^\circ</math> TO THE HORIZONTAL, HENCE <math>\vec{ab}</math> CAN BE DRAWN</p> <p>• THE VELOCITY OF <math>c</math> RELATIVE TO <math>b</math> ACTS AT <math>90^\circ</math> TO <math>BC</math> i.e. <math>80^\circ</math> TO THE HORIZONTAL AND PASSES THROUGH <math>b</math>. VECTOR <math>\vec{cb}</math> IS DRAWN OF INDETERMINATE LENGTH.</p> <p>• THE VELOCITY OF <math>c</math> RELATIVE TO <math>d</math> ACTS AT <math>90^\circ</math> TO <math>DC</math> i.e. AT <math>10^\circ</math> TO THE HORIZONTAL AND PASSES THROUGH <math>d</math>. VECTOR <math>\vec{dc}</math> IS DRAWN, FIXING <math>c</math></p> <p>[DIAGRAM]</p> | <p>(1)</p> <p>(1)</p> <p>(1)</p> <p>(1)</p> <p>(5)</p> |

SCALE  $1 \text{ ms}^{-1} = 5 \text{ cm}$

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$V_{cd} = 1.6 \text{ ms}^{-1}$

[5 MARKS]



EXAMINATION SOLUTIONS: SESSION 2010/2011

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| School:      |                                    |       |          |
| Programme:   |                                    | Year: |          |
| Module/Unit: | STRESS ANALYSIS & DYNAMICS (CONT.) |       |          |
| Author:      |                                    | Page: | 13 of 15 |

| Question No | Question                                                                                                                                                                                                               | Marks |
|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
|             | <p>- THE TANGENTIAL ACCELERATIONS OF C RELATIVE TO B IS <math>\perp</math> TO CB ( &amp; CENTRIFUGAL (CORIOLIS) &amp; PASSES THROUGH C, HENCE VECTOR <math>\vec{C_1C}</math> CAN BE DRAWN AT INDETERMINATE LENGTH.</p> | ①     |
|             | <p>- THE TANGENTIAL ACCELERATION OF C RELATIVE TO D IS <math>\perp</math> TO CD AND PASSES THROUGH <math>C_2</math>, HENCE VECTOR <math>\vec{C_2C}</math> CAN BE DRAWN, FIXING C.</p>                                  | ①     |
|             | <p>- THE RESULTANT ACCELERATION OF b RELATIVE TO C IS THUS GIVEN BY <math>\vec{bc} = \underline{\underline{11.0 \text{ ms}^{-2}}}</math></p>                                                                           | ①     |



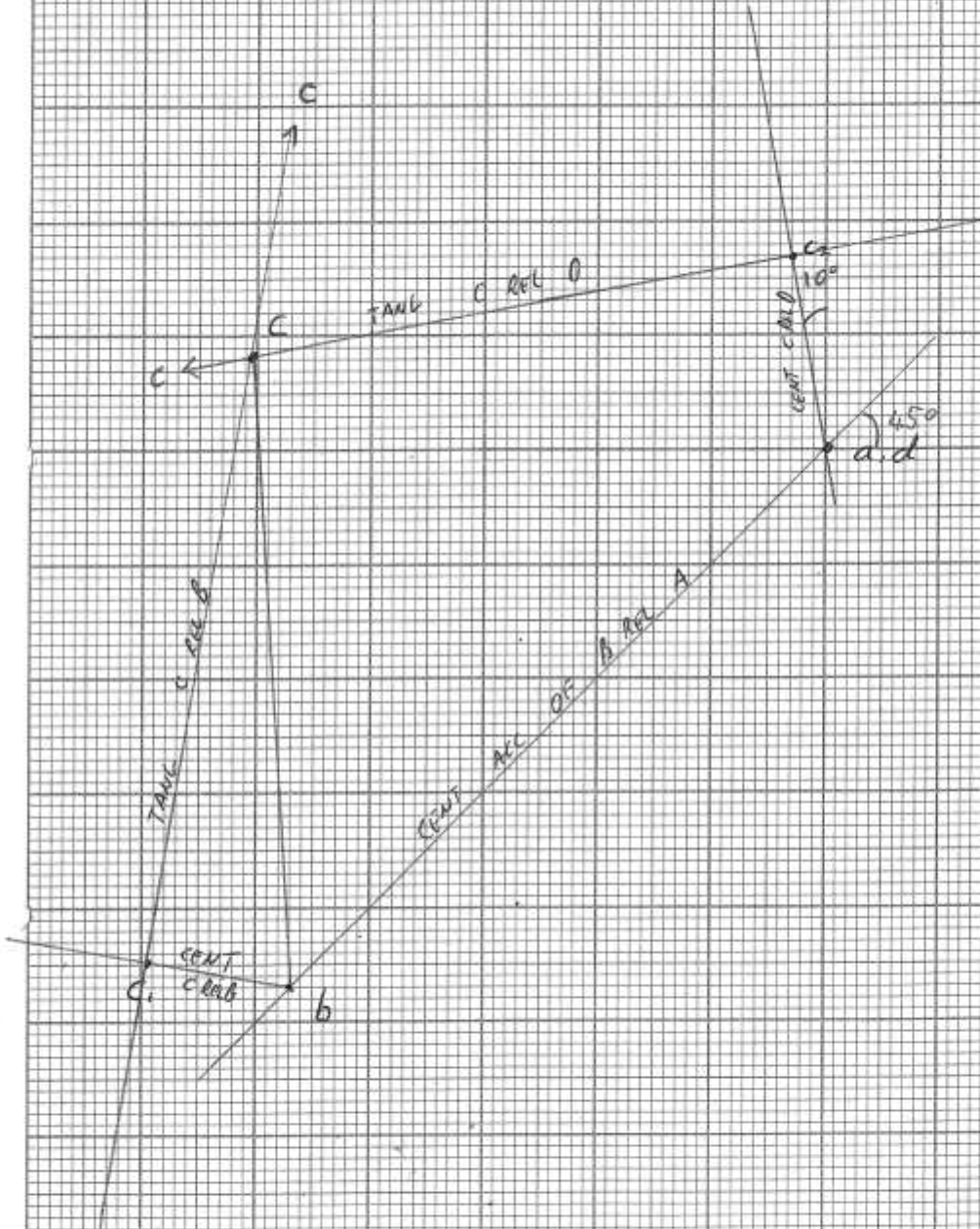
## EXAMINATION SOLUTIONS: SESSION 20 /

|              |                            |
|--------------|----------------------------|
| School:      |                            |
| Programme:   | Year:                      |
| Module/Unit: | STRESS ANALYSIS & DYNAMICS |
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| Question No | Question                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Marks                                       |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|
| (4)(b)      | <p>THE CENTRIPETAL ACCELERATION OF B RELATIVE TO A IS</p> $a_{AB}^c = \left( \frac{70 \times 2\pi}{60} \right)^2 \times 0.25 = 13.43 \text{ ms}^{-2}$ <p>THIS ACTS TOWARDS A, i.e. AT <math>45^\circ</math> TO THE HORIZONTAL. <math>\therefore ab</math> CAN BE DRAWN.</p> <p>THE CENTRIPETAL ACCELERATION OF C RELATIVE TO B ACTS IN THE DIRECTION OF THE LINK BC (i.e. <math>10^\circ</math> TO THE HORIZONTAL) AND IS GIVEN BY</p> $\frac{V_{CB}^2}{CB} = \frac{1.6^2}{1} \leftarrow \text{MEASURED FROM THE VELOCITY DIAGRAM}$ $\therefore V_{CB} = 2.56 \text{ ms}^{-2} \quad \therefore \text{VECTOR } bc \text{ CAN BE DRAWN}$ <p>THE CENTRIPETAL ACCELERATION OF C RELATIVE TO D ACTS IN THE DIRECTION OF THE LINK CD (i.e. <math>10^\circ</math> TO THE VERTICAL) AND IS GIVEN BY</p> $\frac{V_{CD}^2}{CD} = \frac{1.6^2}{0.75} \quad \therefore V_{CD} = 3.41 \text{ ms}^{-2}$ $\therefore \text{VECTOR } dc \text{ CAN BE DRAWN}$ <p>[DIAGRAM]</p> | <p>(1)</p> <p>(1)</p> <p>(1)</p> <p>(4)</p> |

SCALE 1ms = 1cm

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[4 MARKS]