

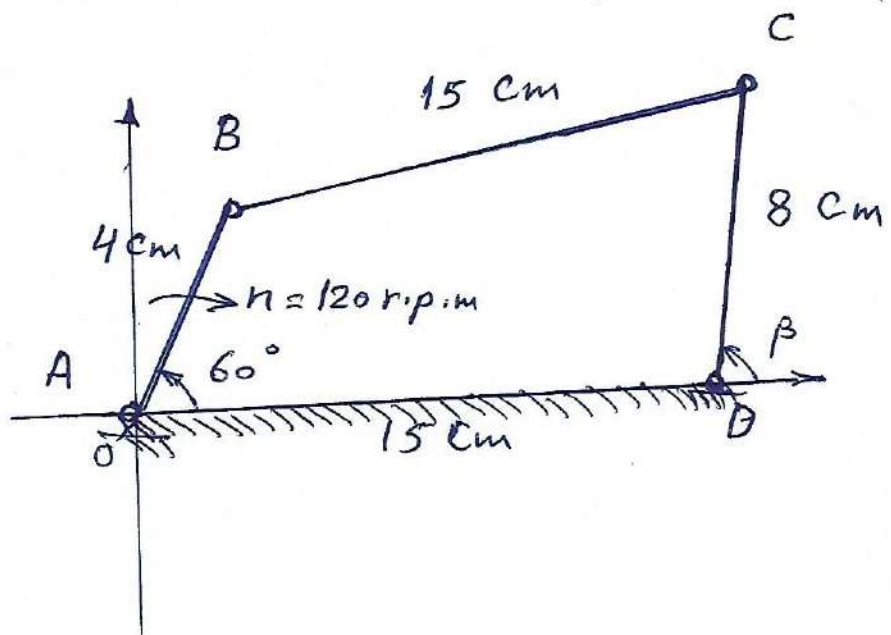
* Example on Velocity and acceleration

1) Example (1) :

In four bar mechanism ABCD as shown in fig(1), AD is fixed and is (15 cm) long, AD and BC are of equal length, the Crank AB is (4 cm) long and rotates at (120) r.p.m in clockwise, while the link CD is (8 cm) oscillates about D. Determine the followings when angle $(\angle BAD = 60^\circ)$

- A- Draw space diagram with suitable scale,
- B- Draw Velocity diagram with suitable scale,
- C- Draw acceleration diagram with suitable scale, and find the angular acceleration of the link (CD)

Fig(1)



Q1: Answer

I) Draw Space diagram with suitable scale.
 Take scale $1\text{m} = 5\text{ mm}$

$$\therefore k_l = \frac{AB}{\bar{AB}} = \frac{4}{4 \times 5} = \frac{1}{5}$$

$$\therefore \begin{cases} \bar{AB} = 4 \times 5 = 20\text{ mm} \\ \bar{BC} = 15 \times 5 = 75\text{ mm} \\ \bar{CD} = 8 \times 5 = 40\text{ mm} \end{cases}$$

II) Velocity diagram

By calculating velocity of link AB

$$V_{AB} = V_{AB}^t + V_{AB}^r = V_B = \omega_{AB} \times AB = \omega_{AB} \times r$$

$$\omega_{AB} = \frac{2\pi N}{60} = \frac{2 \times 3.14 \times 120}{60} = 12.568 \text{ rad/s}$$

$$\therefore V_B = 12.568 \times 4 = 5.03 \text{ cm/s}$$

Assume scale for v

$$1 \text{ cm/s} = 10 \text{ mm}$$

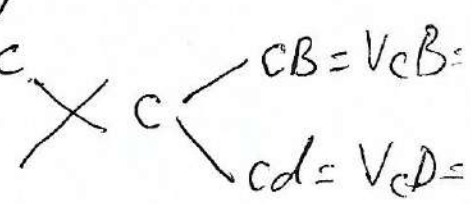
$$\therefore k_v = \frac{V_p}{V_p} = \frac{5.03}{5.03 \times 10} = 0.1$$

Draw V-D by taking pole $a \equiv d$

From A draw line $\parallel V_B = 5.03$ mm

then from b draw line $\perp BC$

and from d draw line $\perp CD$



$$\therefore V_{cB} = 22 \times 0.1 = 2.2 \text{ cm/s}$$

$$V_{cD} = 21 \times 0.1 = 2.1 \text{ cm/s}$$

* Angular velocity of link CD

$$\omega_{cD} = \frac{V_{cD}}{CD} = \frac{2.2}{8} = 0.275 \text{ rad/s}$$

III - Acceleration diagram

$$A_{AB}^{BA} = A_{AB}^{rBA} + A_{AB}^{tBA} = A_{AB}^{rBA} \text{ for fixed point A}$$

$$\therefore A_{AB}^{BA} = A_{AB}^{rBA} = \frac{(V_{AB}^{BA})^2}{AB^{BA}} = \frac{(5.3)^2}{4} = 6.25 \text{ cm/s}^2$$

also $A_{AB}^{rBA} = \omega^2 \times AB^{BA}$

Assume Scale $1 \text{ cm/s}^2 = 10 \text{ mm}$

$$\therefore \tau_{KA} = \frac{A_{AB}}{A_{AB}} = \frac{6.25}{6.25 \times 10} = \frac{6.25}{62.5} = 0.1$$

Take pole $A \equiv D$ and draw

A_{AB} from B to $A = 62.5 \text{ mm}$

$$A_{CB} = A_{CB}^{r} + A_{CB}^{t}$$

$$\therefore A_{CB}^{r} = \frac{(V_{CB})^2}{CB} = \frac{(2.2)^2}{15} = 0.322 \text{ cm/s}^2$$

$$\therefore A_{CB}^{r} = \frac{0.322}{0.1} = 3.22 \text{ mm}$$

$$A_{CD} = \frac{(V_{CD})^2}{CD} = \frac{2.1}{8} = 0.26 \text{ cm/s}^2$$

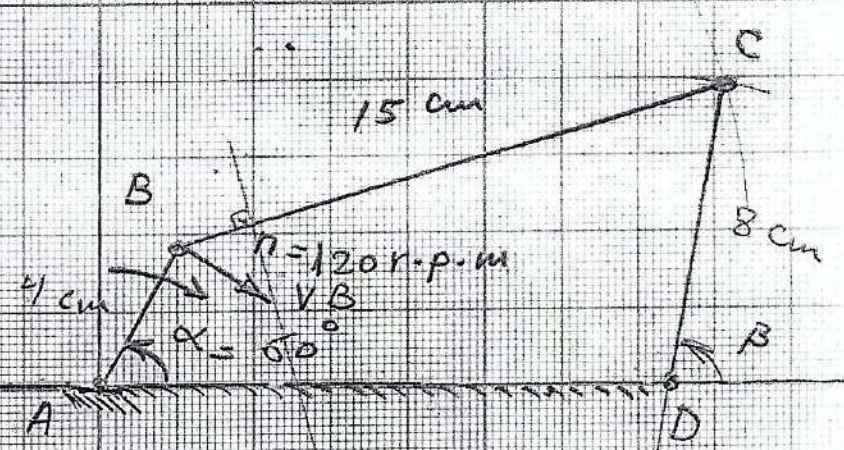
$$\therefore A_{CD} = \frac{0.26}{0.1} = 2.6 \text{ mm}$$

$A_{CB}^{t} \times C \left\{ \begin{array}{l} x_c = A_{CB}^{t} = 60 \times 0.1 = 6 \text{ cm/s}^2 \\ y_c = A_{CD} = 62 \times 0.1 = 6.2 \text{ cm/s}^2 \end{array} \right.$

$$\therefore \alpha_{CD} = \frac{A_{CD}}{CD} = \frac{6.2}{8} = 0.775 \text{ cm/s}^2$$

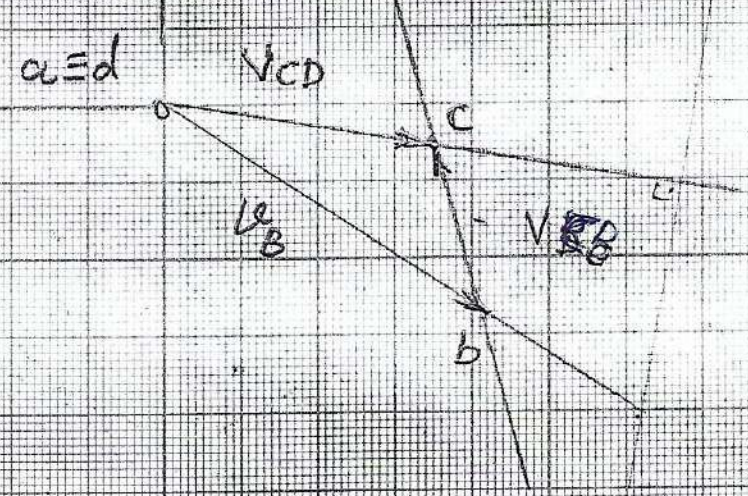
I - Space diagram
S-D

scale 1cm = 5mm
By taking pole of
Coordinate system
(A) = D



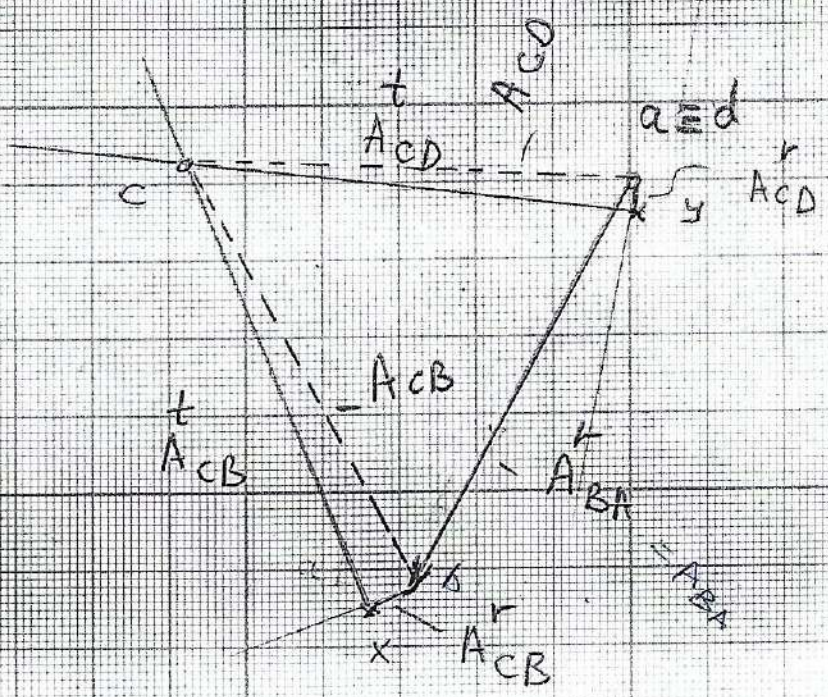
II) V-D
with scale

1cm/s = 10mm
By taking pole a = d



III) A-D
with scale

1cm/s^2 = 1/10 mm
By taking pol a = d

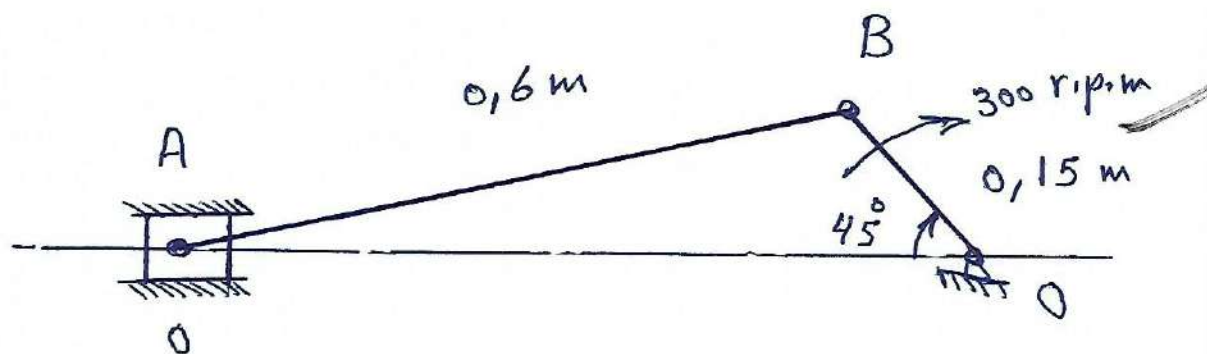


* 2) Example (2):

In the slider crank mechanism, as shown in fig (2), the crank (OB) rotates clockwise at a constant speed of (300) r.p.m., If the crank (OB) is (0,15) m long, and the connecting rod BA is (0,6) m long. Determine the followings:

- 1) Draw space diagram with suitable scale, when the angle $(\angle BOA = 45^\circ)$.
- 2) Draw velocity diagram with suitable diagram.
- 3) Draw acceleration diagram with suitable scale.
- 4) Find the angular velocity and angular acceleration of connecting rod (BA).

Fig (2)



Q 2 Solution

I) Draw space diagram with suitable scale:

1) Assume scale $1 \text{ m} = 100 \text{ mm}$ for length.

$$k_l = \frac{OB \text{ m}}{OB \text{ mm}} = \frac{0,15}{0,15 \times 100} = 0,01 \frac{\text{m}}{\text{mm}}$$

$$\therefore OB = \frac{0,15}{0,01} = 15 \text{ mm}$$

$$BA = \frac{0,6}{0,01} = 60 \text{ mm}$$

II) velocity diagram V-D

$$V_{B0} = \omega_{B0} \times OB = 31,42 \times 0,15 = 4,713 \text{ m/s}$$

$$\omega_{B0} = \frac{2\pi n}{60} = \frac{2 \times 3,14 \times 3000}{60} = 31,42 \text{ rad/s}$$

1) Assume scale for v $1 \text{ m/s} = 6,6 \text{ mm}$

$$k_v = \frac{V_{B0}}{V_{B0} \text{ mm}} = \frac{4,713}{4,713 \times 6,6} = 0,134 \frac{\text{m/s}}{\text{mm}}$$

$$\therefore V_{B0} = 4,713 \text{ m/s} = 31,1 \text{ mm}$$

$$V_{BA} = \omega_{BA} \times k_v = 25 \times 0,134 = 3,4 \text{ m/s}$$

$$V_{A0} = A_0 \times k_v = 30 \times 0,134 = 4 \text{ m}$$

III) acceleration diagram A-D-

$$A_{B0} = A_{B0}^r + A_{B0}^t = A_{B0}^r = \frac{V_{B0}^2}{B_0} = \frac{(4,713)^2}{0,15} = 148,1 \text{ m/s}^2$$

assume scale $1 \text{ m/s}^2 = 0,236$

$$k_A = \frac{A_{B0}}{A_{B0} \text{ mm}} = \frac{A_{B0}}{A_{B0} \times 0,236} = \frac{148}{148 \times 0,236} = 4,3 \frac{\text{m/s}^2}{\text{mm}}$$

$$\therefore A_{B0} = \frac{148,1}{4,3} = 34,4 \text{ mm}$$

Draw A_{B0}^r from $B \rightarrow O = 34,4 \text{ mm}$

$$A_{AB}^r = \frac{V_{AB}^2}{AB} = \frac{(3,4)^2}{0,6} = 19,3 \text{ m/s}^2$$

A_{AB}^t ... -36-

3- الماده: نظريه فلكي
 موضوع (4) المبررات و ساقي محنة
 10- 12- 15- 17- 18- 19- 20- 21- 22- 23- 24- 25- 26- 27- 28- 29- 30- 31- 32- 33- 34- 35- 36- 37- 38- 39- 40- 41- 42- 43- 44- 45- 46- 47- 48- 49- 50- 51- 52- 53- 54- 55- 56- 57- 58- 59- 60- 61- 62- 63- 64- 65- 66- 67- 68- 69- 70- 71- 72- 73- 74- 75- 76- 77- 78- 79- 80- 81- 82- 83- 84- 85- 86- 87- 88- 89- 90- 91- 92- 93- 94- 95- 96- 97- 98- 99- 100- 101- 102- 103- 104- 105- 106- 107- 108- 109- 110- 111- 112- 113- 114- 115- 116- 117- 118- 119- 120- 121- 122- 123- 124- 125- 126- 127- 128- 129- 130- 131- 132- 133- 134- 135- 136- 137- 138- 139- 140- 141- 142- 143- 144- 145- 146- 147- 148- 149- 150- 151- 152- 153- 154- 155- 156- 157- 158- 159- 160- 161- 162- 163- 164- 165- 166- 167- 168- 169- 170- 171- 172- 173- 174- 175- 176- 177- 178- 179- 180- 181- 182- 183- 184- 185- 186- 187- 188- 189- 190- 191- 192- 193- 194- 195- 196- 197- 198- 199- 200- 201- 202- 203- 204- 205- 206- 207- 208- 209- 210- 211- 212- 213- 214- 215- 216- 217- 218- 219- 220- 221- 222- 223- 224- 225- 226- 227- 228- 229- 230- 231- 232- 233- 234- 235- 236- 237- 238- 239- 240- 241- 242- 243- 244- 245- 246- 247- 248- 249- 250- 251- 252- 253- 254- 255- 256- 257- 258- 259- 260- 261- 262- 263- 264- 265- 266- 267- 268- 269- 270- 271- 272- 273- 274- 275- 276- 277- 278- 279- 280- 281- 282- 283- 284- 285- 286- 287- 288- 289- 290- 291- 292- 293- 294- 295- 296- 297- 298- 299- 300- 301- 302- 303- 304- 305- 306- 307- 308- 309- 310- 311- 312- 313- 314- 315- 316- 317- 318- 319- 320- 321- 322- 323- 324- 325- 326- 327- 328- 329- 330- 331- 332- 333- 334- 335- 336- 337- 338- 339- 340- 341- 342- 343- 344- 345- 346- 347- 348- 349- 350- 351- 352- 353- 354- 355- 356- 357- 358- 359- 360- 361- 362- 363- 364- 365- 366- 367- 368- 369- 370- 371- 372- 373- 374- 375- 376- 377- 378- 379- 380- 381- 382- 383- 384- 385- 386- 387- 388- 389- 390- 391- 392- 393- 394- 395- 396- 397- 398- 399- 400- 401- 402- 403- 404- 405- 406- 407- 408- 409- 410- 411- 412- 413- 414- 415- 416- 417- 418- 419- 420- 421- 422- 423- 424- 425- 426- 427- 428- 429- 430- 431- 432- 433- 434- 435- 436- 437- 438- 439- 440- 441- 442- 443- 444- 445- 446- 447- 448- 449- 450- 451- 452- 453- 454- 455- 456- 457- 458- 459- 460- 461- 462- 463- 464- 465- 466- 467- 468- 469- 470- 471- 472- 473- 474- 475- 476- 477- 478- 479- 480- 481- 482- 483- 484- 485- 486- 487- 488- 489- 490- 491- 492- 493- 494- 495- 496- 497- 498- 499- 500- 501- 502- 503- 504- 505- 506- 507- 508- 509- 510- 511- 512- 513- 514- 515- 516- 517- 518- 519- 520- 521- 522- 523- 524- 525- 526- 527- 528- 529- 530- 531- 532- 533- 534- 535- 536- 537- 538- 539- 540- 541- 542- 543- 544- 545- 546- 547- 548- 549- 550- 551- 552- 553- 554- 555- 556- 557- 558- 559- 560- 561- 562- 563- 564- 565- 566- 567- 568- 569- 570- 571- 572- 573- 574- 575- 576- 577- 578- 579- 580- 581- 582- 583- 584- 585- 586- 587- 588- 589- 590- 591- 592- 593- 594- 595- 596- 597- 598- 599- 600- 601- 602- 603- 604- 605- 606- 607- 608- 609- 610- 611- 612- 613- 614- 615- 616- 617- 618- 619- 620- 621- 622- 623- 624- 625- 626- 627- 628- 629- 630- 631- 632- 633- 634- 635- 636- 637- 638- 639- 640- 641- 642- 643- 644- 645- 646- 647- 648- 649- 650- 651- 652- 653- 654- 655- 656- 657- 658- 659- 660- 661- 662- 663- 664- 665- 666- 667- 668- 669- 670- 671- 672- 673- 674- 675- 676- 677- 678- 679- 680- 681- 682- 683- 684- 685- 686- 687- 688- 689- 690- 691- 692- 693- 694- 695- 696- 697- 698- 699- 700- 701- 702- 703- 704- 705- 706- 707- 708- 709- 710- 711- 712- 713- 714- 715- 716- 717- 718- 719- 720- 721- 722- 723- 724- 725- 726- 727- 728- 729- 730- 731- 732- 733- 734- 735- 736- 737- 738- 739- 740- 741- 742- 743- 744- 745- 746- 747- 748- 749- 750- 751- 752- 753- 754- 755- 756- 757- 758- 759- 760- 761- 762- 763- 764- 765- 766- 767- 768- 769- 770- 771- 772- 773- 774- 775- 776- 777- 778- 779- 780- 781- 782- 783- 784- 785- 786- 787- 788- 789- 790- 791- 792- 793- 794- 795- 796- 797- 798- 799- 800- 801- 802- 803- 804- 805- 806- 807- 808- 809- 810- 811- 812- 813- 814- 815- 816- 817- 818- 819- 820- 821- 822- 823- 824- 825- 826- 827- 828- 829- 830- 831- 832- 833- 834- 835- 836- 837- 838- 839- 840- 841- 842- 843- 844- 845- 846- 847- 848- 849- 850- 851- 852- 853- 854- 855- 856- 857- 858- 859- 860- 861- 862- 863- 864- 865- 866- 867- 868- 869- 870- 871- 872- 873- 874- 875- 876- 877- 878- 879- 880- 881- 882- 883- 884- 885- 886- 887- 888- 889- 890- 891- 892- 893- 894- 895- 896- 897- 898- 899- 900- 901- 902- 903- 904- 905- 906- 907- 908- 909- 910- 911- 912- 913- 914- 915- 916- 917- 918- 919- 920- 921- 922- 923- 924- 925- 926- 927- 928- 929- 930- 931- 932- 933- 934- 935- 936- 937- 938- 939- 940- 941- 942- 943- 944- 945- 946- 947- 948- 949- 950- 951- 952- 953- 954- 955- 956- 957- 958- 959- 960- 961- 962- 963- 964- 965- 966- 967- 968- 969- 970- 971- 972- 973- 974- 975- 976- 977- 978- 979- 980- 981- 982- 983- 984- 985- 986- 987- 988- 989- 990- 991- 992- 993- 994- 995- 996- 997- 998- 999- 1000

الماده: نظريه فلكي
 موضوع (4) المبررات و ساقي محنة

$$A_{A0} = A_{A0}^+ + A_{A0}^- = A_{A0}^+$$

$$A_{A0}^+ \times a \left\{ \begin{array}{l} a_{\alpha} = A_{A0} = \omega_{\alpha} \times r_A = \\ a_{\chi} = A_{AB}^+ = \alpha_{\chi} \times r_A = \end{array} \right.$$

$$\therefore A_{A0}^+ = 25 \times 4,3 = 107,5 \text{ m/s}^2$$

$$A_{AB}^+ = 24 \times 4,3 = 103,8 \text{ m/s}^2$$

and $A_{AB \text{ total}} = 28,6 \times 4,3 = 122,8 \text{ m/s}^2$

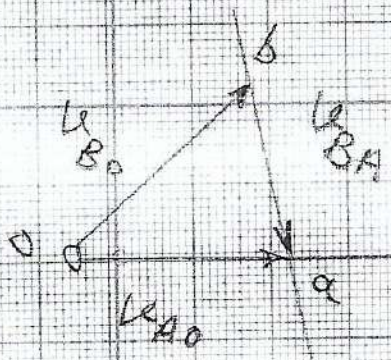
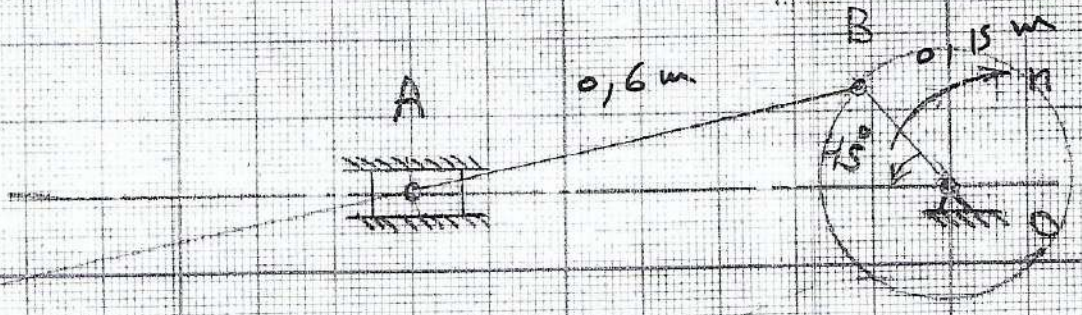
IV) 1) angular velocity of AB

$$\omega_{AB} = \frac{V_{AB}}{AB} = \frac{3,4}{0,6} = 5,67 \text{ rad/s}$$

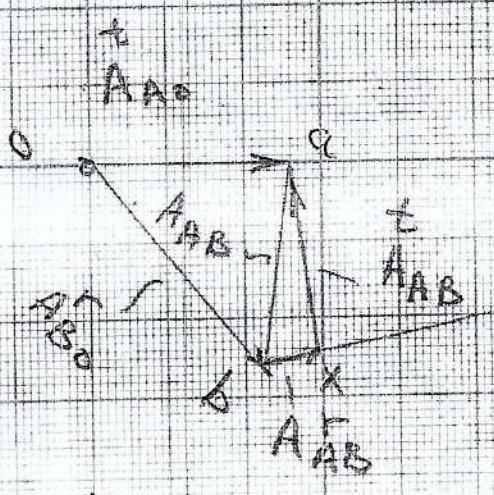
V) angular acceleration of AB

$$\alpha = \frac{a_{AB}^+}{AB} = \frac{103}{0,6} = 171,67 \text{ rad/s}^2$$

① \vec{M}
I, Draw D-S-D



II - V - D



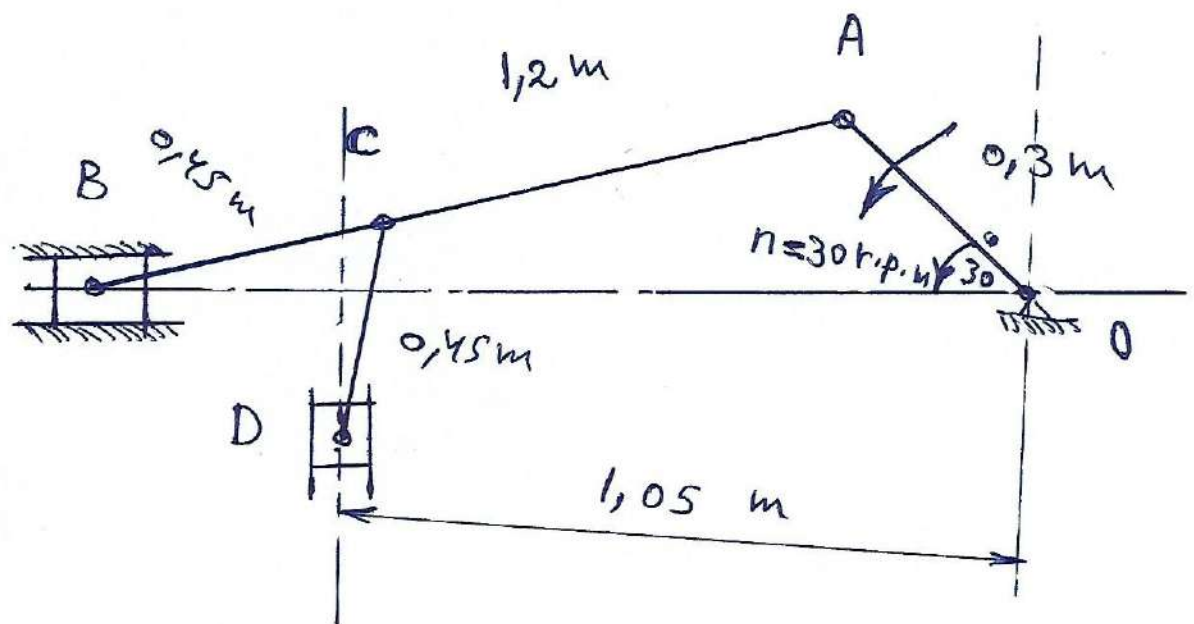
III) A - D

3) Example(3)

In the figure (3) as shown below, the Crank (OA) rotates at speed (20) r.p.m anticlock wise, and gives motion to the sliding blocks B and D. The dimensions of the various links are (OA = 0,3) m, (AB = 1,2) m, (BC = 0,45) m and (CD = 0,45) m.

Determine the followings when the ang (AOB = 30°)

1. Space diagram with suitable scale.
2. Velocity diagram with suitable scale.
3. linear acceleration of the slider D.



Fig(3)

Q3: Solution: $AB = 1,2 \text{ m}$, $BC = 0,45 \text{ m}$,
 $CD = 0,45 \text{ m}$, $OA = 0,3 \text{ m}$ المسافة

Draw S-D with suitable scale.

Assume scale $1 \text{ m} = 50 \text{ mm}$

$$k_s = \frac{OA}{OA} = \frac{0,3 \text{ m}}{0,3 \times 50 \text{ mm}} = 0,02 \text{ m/mm}$$

المقياس = كل الورقة المسافة

$$OA = \frac{0,3}{0,02} = 15 \text{ mm}, \quad CD = BC = \frac{0,45}{0,02} = 22,5 \text{ mm}$$

$$AB = \frac{1,2}{0,02} = 60 \text{ mm} \quad \text{المسافة الورقة}$$

II) Draw V-D with suitable scale

$$V_{AO} = \omega_A = \omega \times OA \quad \perp OA \text{ in direction of } \omega$$

$$= \frac{2\pi N}{60} \times AO = \frac{2 \times 3,14 \times 20}{60} \times 0,3 = 0,63 \text{ m/s}$$

Assume scale $1 \text{ m/s} = 55 \text{ mm}$

$$k_v = \frac{V_A}{V_A} = \frac{0,63}{0,63 \times 55} = 0,018$$

$$\therefore V_A = 35 \text{ mm}$$

$$V_{BA} \left[\begin{array}{l} \text{from } a \perp AB \\ \text{from } o \parallel B_o \end{array} \right] \times b \left[\begin{array}{l} ab \times k_v = V_{AB} \\ ob \times k_v = V_{Bo} \end{array} \right]$$

$$\therefore \left[\begin{array}{l} 30 \times 0,018 = 0,54 \text{ m/s} \\ 22 \times 0,018 = 0,4 \text{ m/s} \end{array} \right]$$

For determining V_e by dividing in same ratio

$$\frac{Bc}{BA} = \frac{bc}{ba} = \frac{22,5 \text{ mm}}{60 \text{ mm}} = \frac{bc}{30 \text{ mm}} \Rightarrow bc = \frac{22,5 \times 30}{60} = 11,25 \text{ mm}$$

$$V_{CD} = \bar{c}o = 24 \times k_v = 24 \times 0,018 = 0,43 \text{ m/s}$$

$$V_{D_o} = d\bar{o} \times k_v = 18,4 \times 0,018 = 0,24 \text{ m/s}$$

$$V_{CD} \rightarrow \left[\begin{array}{l} \text{from } e \perp CD \\ \text{from } o \parallel D_o \end{array} \right] \times d \left[\begin{array}{l} de = V_{DC} = dc \times k_v \\ od = V_{D_o} = do \times k_v \end{array} \right]$$

Q1

III, Acceleration A-D

Acceleration of point A w.r.t O

$$A_{Ao} = A_{Ao}^r + A_{Ao}^t = A_{Ao}^r = \frac{VAo^2}{Ao} = \frac{(0,63)^2}{0,3m} = 1,3 \text{ m/s}^2$$

also $A_{Ao}^t = \omega^2 * Ao$

Assume S. Scale for A $\Rightarrow 1 \text{ m/s}^2 = 27 \text{ mm}$

$$k_A = \frac{AA}{\bar{AA}} = \frac{1,3}{1,3 * 27} = \frac{1,3}{35} = 0,037$$

\therefore From O $= A_{Ao} \neq A_O$

For $A_{BA} = A_{BA}^r + A_{BA}^t$

$$A_{BA}^r = \frac{V_{BA}^2}{BA} = \frac{(0,54)^2}{1,2} = 0,243 \text{ m/s}^2 = \frac{0,243}{0,037} = 6,6 \text{ mm}$$

$A_{BA} \perp A_{BA}^r \rightarrow$ from X

For $A_{Bo} = A_{Bo}^t + A_{Bo}^r = A_{Bo}^t \rightarrow$ from O // Bo

$$\begin{cases} = A_{BA}^t = 17 \text{ mm} * k_A = 17 * 0,037 = 0,629 \text{ m/s}^2 \\ = A_{Bo}^t = 35 \text{ mm} * k_A = 35 * 0,037 = 1,295 \text{ m/s}^2 \end{cases}$$

for A_c - by dividing in same ratio

$$\frac{BC}{BA} = \frac{bc}{ba} = \frac{22,5 \text{ mm}}{60 \text{ mm}} = \frac{bc}{18 \text{ mm}} \Rightarrow bc = \frac{22,5 * 18}{60} = 6,75 \text{ mm}$$

$$\therefore A_c = C_o * k_v = 34 \text{ mm} * 0,037 = 1,26 \text{ m/s}^2$$

for $A_{Dc} = A_{Dc}^r + A_{Dc}^t$

$$A_{Dc}^r = \frac{(V_{Dc})^2}{Dc}$$

$A_{Dc}^t + Dc$ from d

for $A_{Do} = A_{Do}^t + A_{Do}^r = A_{Do}^t \rightarrow$ from O // Do

$$\begin{cases} = 34,6 \text{ mm} * k_A = 34,6 * 0,037 = 1,28 \text{ m/s}^2 \\ = 4,5 \text{ mm} * k_A = 4,5 * 0,037 = 0,16 \text{ m/s}^2 \end{cases}$$

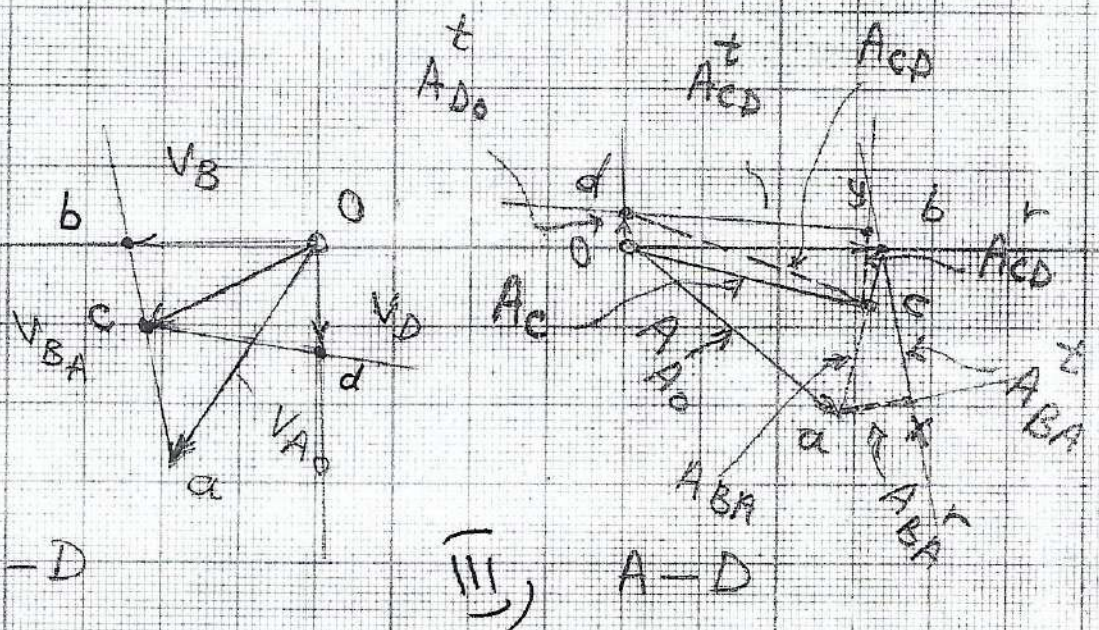
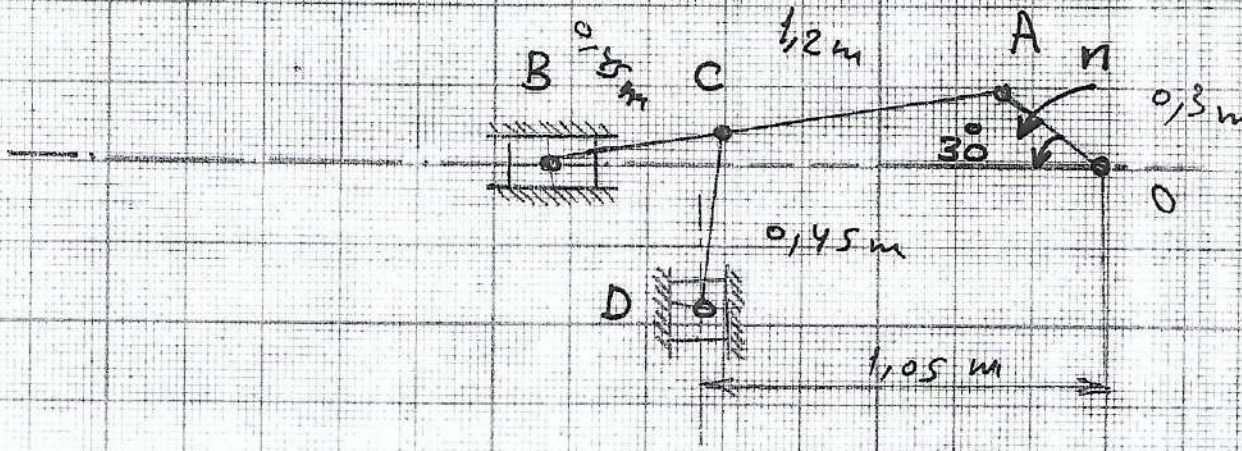
\therefore for Angular acceleration for p. @ w.r.t D \Rightarrow CD

$1,28 \text{ m/s}^2$ \rightarrow $0,16 \text{ m/s}^2$ A.c.w

Q1: solution:

c - ايجاد السرعة الزاوية للذراع (A) في لحظة

I) S-D



II) V-D

III) A-D

$\therefore A_{D0} = 4,5 \text{ mm} \times \omega_A = 4,5 \times 0,037 = 0,16 \text{ m/s}^2$

- 44 -

4) Example (4)

In the figure (4) as shown below, a toggle mechanism in which the crank OP rotates at uniform speed of (120) r.p.m in a clockwise direction. The lengths of the various links are as follow: ($OP = 8$) cm, ($PR = 18$) cm, ($QR = 24$) cm and ($SR = 27$) cm.

Determine the followings, when the $\text{ang } (OPQ) = 45^\circ$.

- 1) Space diagram with suitable scale,
- 2) Velocity diagram with suitable scale,
- 3) Linear acceleration of the slider (S).

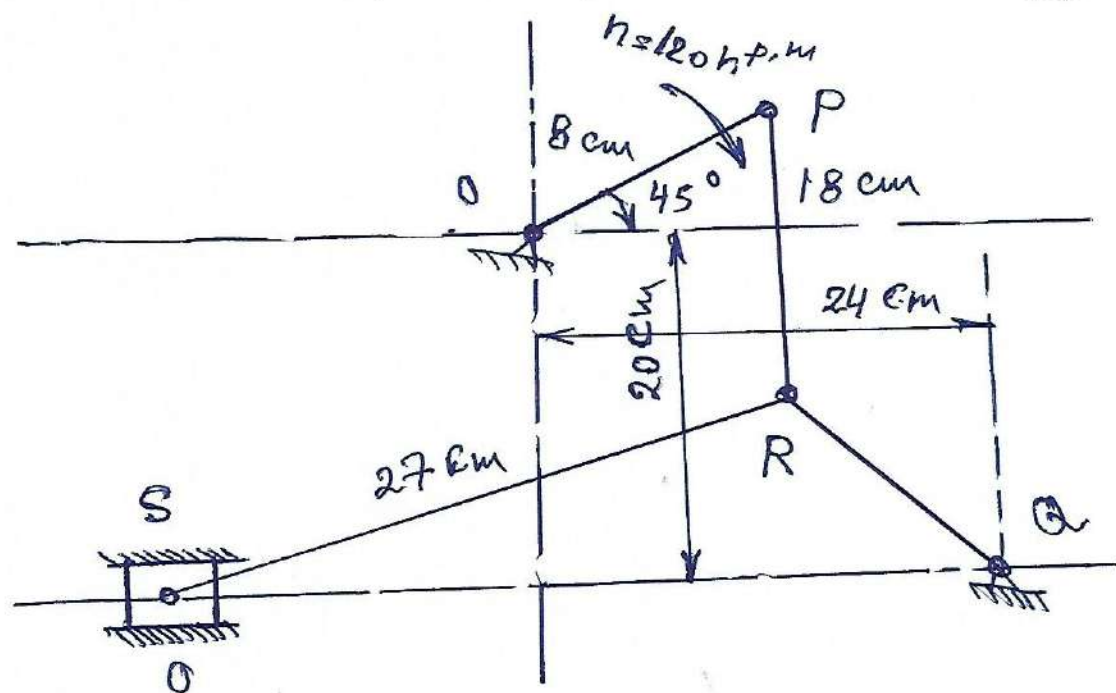


Fig (4)

②: Solution

I) Draw space diagram with suitable scale
assume scale $1 \text{ cm} = 2 \text{ mm}$

$$\therefore k_e = \frac{OP}{\overline{OP}} = \frac{8}{8 \times 2} = 0,5 \frac{\text{cm}}{\text{mm}}$$

$$\therefore OP = \frac{8 \text{ cm}}{k_e} = 16 \text{ mm}$$

$$PR = \frac{18 \text{ cm}}{k_e} = 36 \text{ mm}$$

$$QR = \frac{24 \text{ cm}}{k_e} = 48 \text{ mm}$$

$$SR = \frac{27}{k_e} = 54 \text{ mm}$$

II) Velocity diagrams

$$V_{P0} = \omega \times P_0 = \frac{2\pi N}{60} \times P_0 = \frac{2 \times 3,14 \times 120}{60} \times 8 =$$

$$\therefore V_{P0} = 100,5 \text{ cm/s}$$

Assume scale: $1 \text{ cm/s} = \frac{1}{5} \text{ mm}$

$$\therefore k_v = \frac{V_P}{\overline{V_P}} = \frac{100,5}{100,5 \times \frac{1}{5}} = 5 \text{ cm/s/mm}$$

$$\therefore V_{P0} = \frac{100,5}{5} = 20,1 \text{ mm}$$

Draw $V_{P0} \perp OP = 20,1 \text{ mm}$ from o.

$$V_{RP} \left\{ \begin{array}{l} \text{From } P \perp RP \\ \text{From } r \perp RP \end{array} \right. \times r \left[\begin{array}{l} r_p \times k_v = V_{RP} \\ r_q \times k_v = V_{RQ} \end{array} \right.$$

$$V_{RQ} \left\{ \begin{array}{l} \text{From } q \perp RQ \\ \text{From } r \perp RQ \end{array} \right. \times r \left[\begin{array}{l} r_p \times k_v = V_{RP} \\ r_q \times k_v = V_{RQ} \end{array} \right.$$

$$\therefore \left\{ \begin{array}{l} V_{RP} = 18,4 \times 5 = 92 \text{ cm/s} \\ V_{RQ} = 10,8 \times 5 = 54 \text{ cm/s} \end{array} \right. \text{ relative velocity}$$

$$\left\{ \begin{array}{l} V_{SR} = 10,8 \times 5 = 54 \text{ cm/s} \\ V_{SQ} = 7,2 \times 5 = 36 \text{ cm/s} \end{array} \right. \text{ velocity}$$

$$V_{SR} \left\{ \begin{array}{l} \text{From } r \perp SR \\ \text{From } s \perp SR \end{array} \right. \times s \left[\begin{array}{l} s_r \times k_v = V_{SR} \\ s_q \times k_v = V_{SQ} \end{array} \right.$$

$$V_{SQ} \left\{ \begin{array}{l} \text{From } q \perp SQ \\ \text{From } s \perp SQ \end{array} \right. \times s \left[\begin{array}{l} s_r \times k_v = V_{SR} \\ s_q \times k_v = V_{SQ} \end{array} \right.$$

$$\therefore \left\{ \begin{array}{l} V_{SR} = 10,8 \times 5 = 54 \text{ cm/s} \\ V_{SQ} = 7,2 \times 5 = 36 \text{ cm/s} \end{array} \right.$$

$$\left\{ \begin{array}{l} V_{SR} = 10,8 \times 5 = 54 \text{ cm/s} \\ V_{SQ} = 7,2 \times 5 = 36 \text{ cm/s} \end{array} \right.$$

Q₁ : Solution

III) Acceleration diagram

$$A_{po} = A_{po}^r + A_{po}^t = 0 = A_{po}$$

$$\therefore A_{po}^r = \frac{V_{po}^2}{p_o} = \frac{100,5}{8^2} = 1262,5 \text{ cm/s}^2$$

Assume Scale: $1 \text{ cm/s}^2 = \frac{1}{40} \text{ mm}$

$$\therefore k_A = \frac{OP}{OP} = \frac{1262,5}{1262,5 \times \frac{1}{40}} = 40,7 \frac{\text{cm/s}^2}{\text{mm}}$$

\therefore for A_{po} draw $op \parallel OP$ from $O = \frac{1262,5}{40,7} = \frac{1262,5}{40,7} = 31$

* a_{rp} $\left[\begin{array}{l} a_{rp}^r = \frac{V_{rp}^2}{RP} = \frac{(92)^2}{18} = 470,2 \text{ cm/s}^2 \\ \therefore a_{rp}^r = \frac{470,2}{40,7} = \frac{470,2}{40,7} = 11,5 \text{ mm, from R} \rightarrow 1 \end{array} \right.$

* a_{rq} $\left[\begin{array}{l} a_{rq}^r = \frac{V_{rq}^2}{RQ} = \frac{54^2}{24} = 121,5 \frac{\text{cm}}{\text{s}^2} \times \frac{1}{40,7} = 2,98 \\ \text{draw from R} \rightarrow Q \end{array} \right.$

and $\left[\begin{array}{l} a_{rp}^t \\ a_{rq}^t \end{array} \right] \times r \left[\begin{array}{l} x_r = a_{rp}^t \\ y_r = a_{rq}^t \end{array} \right.$

by joining $rp \rightarrow a_{rp}$ total, $rq \rightarrow a_{rq}$ total

and $\left[\begin{array}{l} a_{sr}^r = \frac{V_{sr}^2}{SR} = \frac{54^2}{27} = 108 \text{ cm/s}^2 \times \frac{1}{40,7} = 2,65 \text{ mm} \\ a_{sr}^t + a_{sr}^r \rightarrow \text{from} \end{array} \right.$

and $\left[\begin{array}{l} a_{sq}^r = 0 \\ a_{sq}^t = s_q \end{array} \right.$

$\therefore \left[\begin{array}{l} a_{sr}^t \\ a_{sq}^t \end{array} \right] \times s \left[\begin{array}{l} z_s = a_{sr}^t \\ s_q = a_{sq}^t = a_s = 4,42 \text{ mm} \times \frac{1}{40,7} = 108 \end{array} \right.$

by joining $sr \rightarrow a_{sr}$ total

I, S-D

$OP = 16 \text{ mm}$

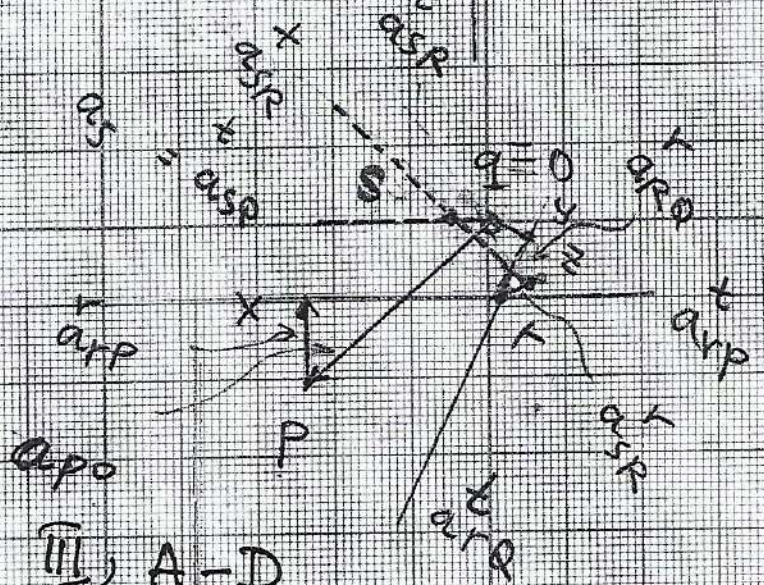
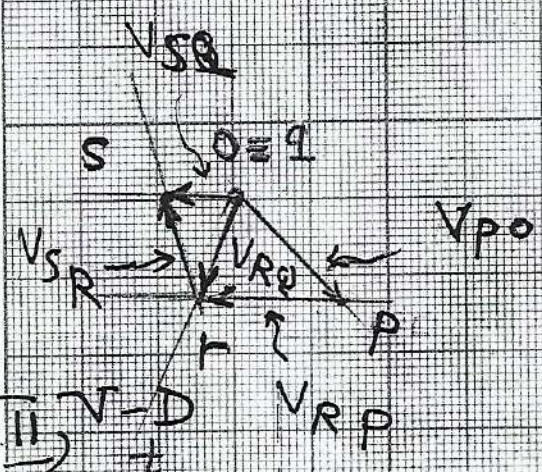
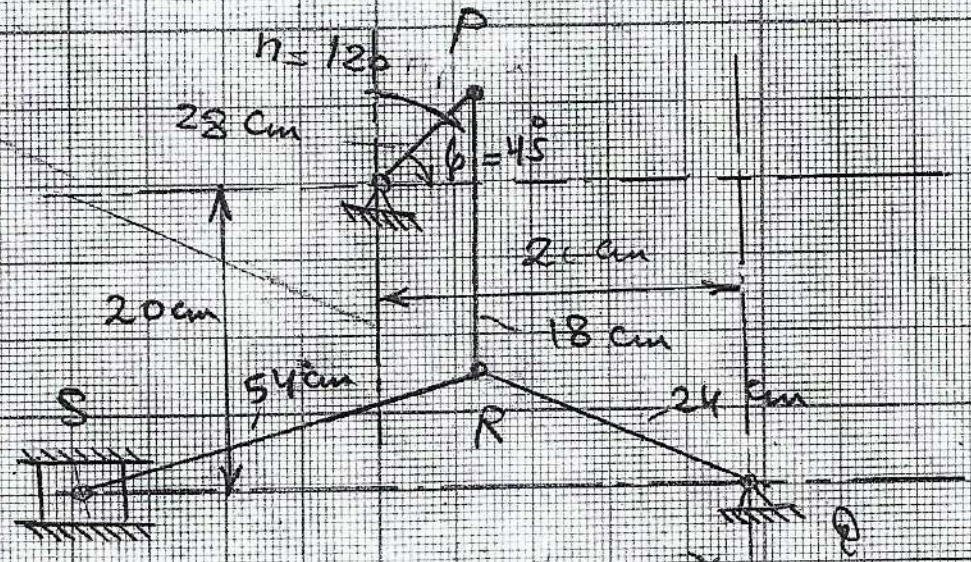
$DR = 36 \text{ mm}$

$QR = 48 \text{ mm}$

$SR = 54 \text{ mm}$

$\phi = 45^\circ$

$n = 120 \text{ r.p.m}$



II, V-D

III, A-D

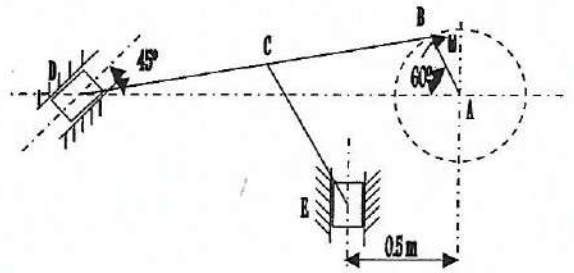
$\therefore a_{SR} = a_S = 4 \text{ mm} \times \omega^2 = 4,4 \times 40,7^2 = 180 \text{ cm/s}^2$

[Signature]

(Home works)

Q1/ The dimensions of the mechanism shown are as follows:

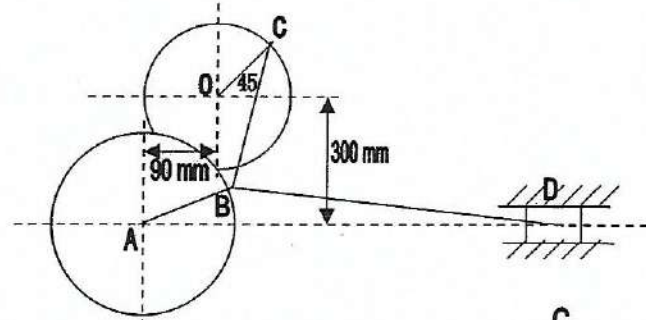
$AB = 0.45 \text{ m}$; $BD = 1.5 \text{ m}$; $BC = CE = 0.9 \text{ m}$. The crank AB turns uniformly at 180 rpm in the clockwise direction and the blocks at D and E are working in frictionless guides. Draw the velocity diagram for the mechanism and find the velocities of the sliders D and E in their guides.



Q2/ In the toggle mechanism shown in figure below, D is constrained to move on a horizontal path. The dimensions of various links are as follows:

$AB = 200 \text{ mm}$; $BC = 300 \text{ mm}$; $OC = 150 \text{ mm}$; and $BD = 450 \text{ mm}$.

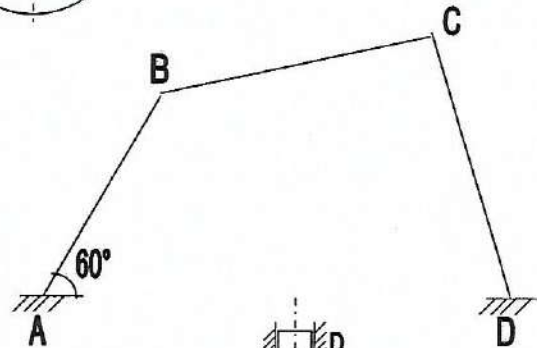
The crank OC is rotating in a counter clockwise direction at a speed of 180 rpm . Find the velocity of D , and angular velocity of BD .



Q3/ The dimensions and configuration of the four bar mechanism shown in figure are as follows:

$AB = 30 \text{ cm}$, $CD = 36 \text{ cm}$, $BC = 36 \text{ cm}$ and $AD = 60 \text{ cm}$.

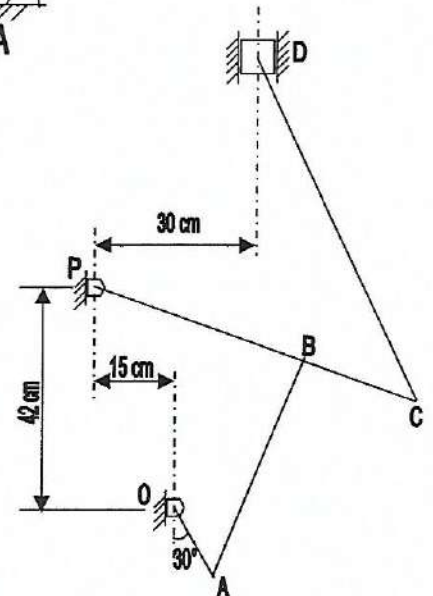
The crank AB has an angular velocity of 10 rad/sec clockwise. Determine the angular velocity of DB and BC and velocity of the joint C .



Q4/ Find out the velocity of the slider D and the angular velocity of link CD for the engine mechanism shown in figure. The dimensions of the various links are

$OA = 15 \text{ cm}$; $AB = 45 \text{ cm}$; $PB = 24 \text{ cm}$; $BC = 21 \text{ cm}$;

$CD = 66 \text{ cm}$ and $N_{OA} = 180 \text{ rpm}$.

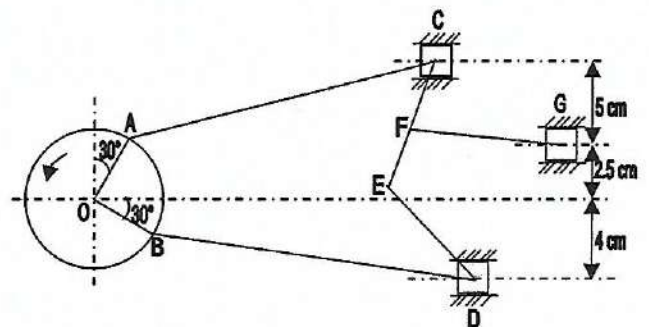


Q5/ In the mechanism shown in figure OA and OB are two equal cranks at right angle rotating about O at a speed of 40 rpm anticlockwise. The dimensions of the various links as follows:

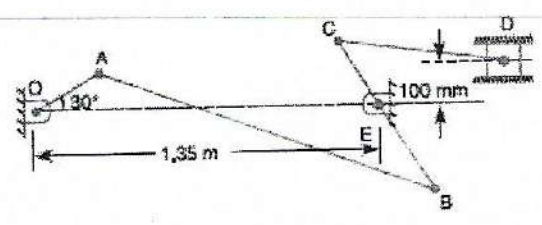
$OA = OB = 5 \text{ cm}$; $AC = BD = 17.5 \text{ cm}$;

$DE = CE = 7.5 \text{ cm}$; $FG = 11.5 \text{ cm}$ and

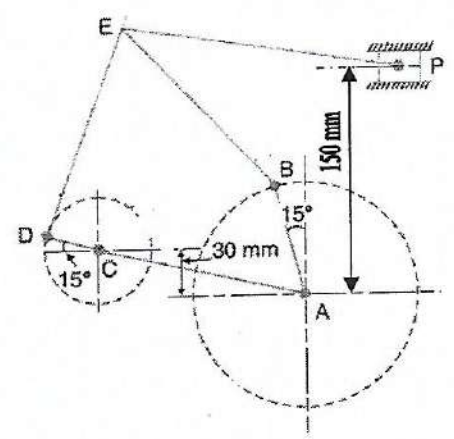
$EF = FC$. Find the velocity of the slider G .



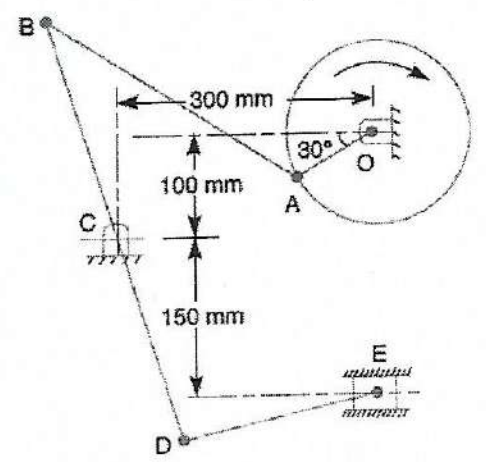
Q6/A mechanism, as shown in figure, have the following dimensions:
 $OA = 200 \text{ mm}$; $AB = 1.5 \text{ m}$; $BC = 600 \text{ mm}$; $CD = 500 \text{ mm}$
 and $BE = 400 \text{ mm}$. If crank OA rotates uniformly at 120 rpm clockwise, find (1) the velocity of B , C and D (2) the angular velocity of the links AB , BC and CD .



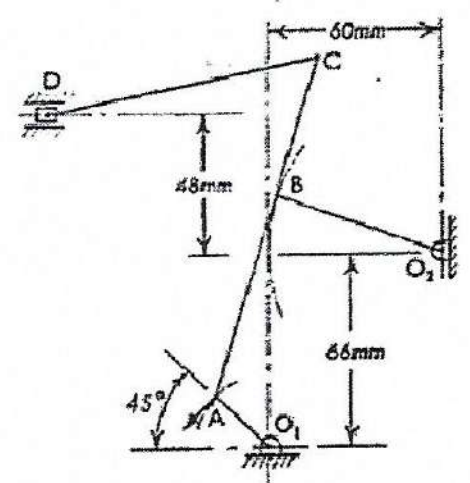
Q7/ In a mechanism shown in figure, the dimensions are as follows: $AB = 80 \text{ mm}$; $CD = 40 \text{ mm}$; $BE = DE = 150 \text{ mm}$; $AC = 150 \text{ mm}$; and $EP = 200 \text{ mm}$. The speed of the crank CD is 1140 rpm and of the crank AB is 570 rpm clockwise. Determine the velocity of the piston P for the given configuration.



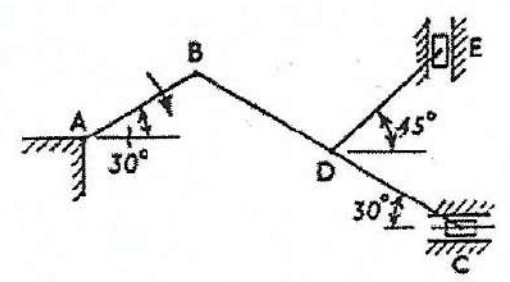
Q8/ In a mechanism as shown in figure, the crank OA is 100 mm long and rotates in a clockwise direction at a speed of 100 rpm . The straight rod BCD rocks on a fixed point at C . The links BC and CD are each 200 mm long and the link AB is 300 mm long. The slider E , which is driven by the rod DE is 250 mm long. Find the velocity of E .



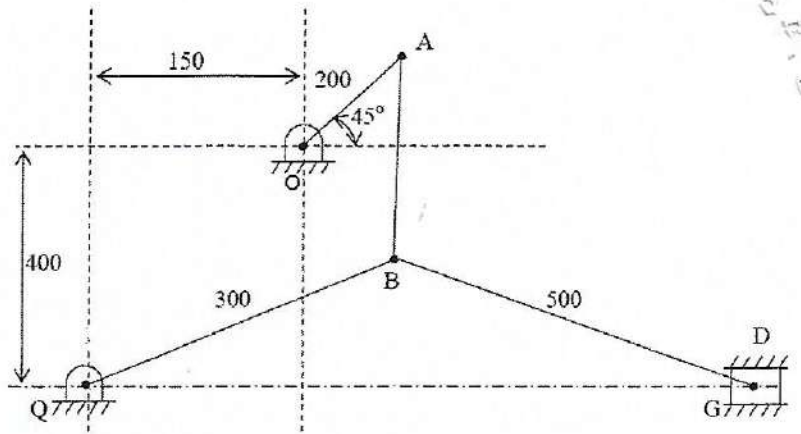
Q9/ The diagram of a linkage is given in Fig. below. Find the velocity of the slider D and the angular velocity of DC , when the crank O_1A is in the given position and the speed of rotation is 90 rev/min anticlockwise. $O_1A = 24 \text{ mm}$, $O_2B = 60 \text{ mm}$, $CD = 96 \text{ mm}$, $AB = 72 \text{ mm}$, $CB = 48 \text{ mm}$.



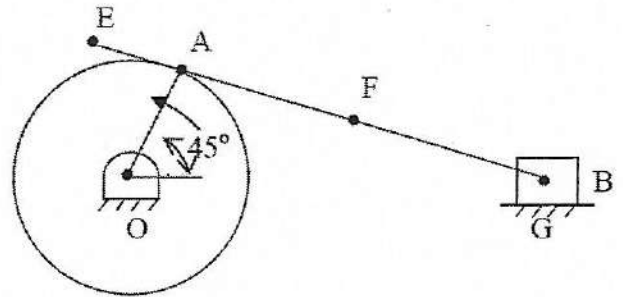
Q10/ In the mechanism shown in Fig., the crank AB is 75 mm long and rotate uniformly clockwise at 8 rad/sec . Given that $BD = DC = DE$; $BC = 300 \text{ mm}$, draw the velocity diagrams, and find the velocity of the pistons at C and E .



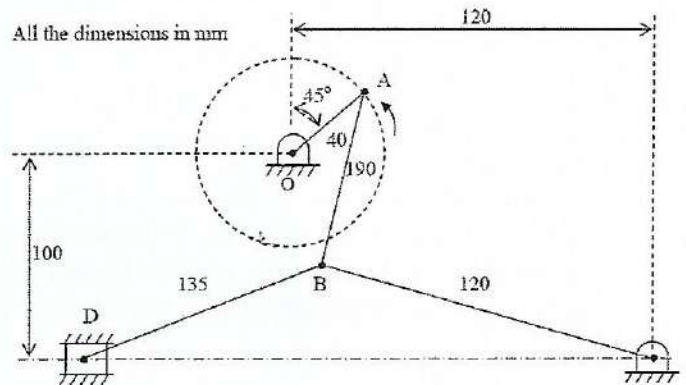
Q11/ In a toggle mechanism shown in figure the crank OA rotates at 210 rpm counter clockwise. Determine the velocity of slider D and angular velocity of link BD.



Q12/ In a slider crank mechanism the crank OA is 200 mm long and rotates at 40 rad/sec in a counter clockwise direction. The length of the connecting rod AB is 800 mm. Determine,
 i) The velocity of the slider B.
 ii) Velocity of point E located at a distance of 200 mm on the connecting rod extended.
 iii) The position and velocity of point F on the connecting rod having the least absolute velocity.
 iv) The angular velocity of connecting rod.



Q13/ Figure below shows a toggle mechanisms in which the crank OA rotates at 120 rpm. Find the velocity of the slider D.



Q14/ A toggle mechanism is shown in figure along with the diagrams of the links in mm. find the velocities of the points B and C and the angular velocities of links AB. The crank rotates at 50 rpm in the clockwise direction.

