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S. No.	Date	Title Da V	Your Per Page No.	Teacher's song Exams Gu Sign 7 s Gu Remarks
J.		Time and space analysis.		
X.		sorthing Techniques. 2		
3.		Gereedy Algorithms. 3		
X.		Dijkstrea Algorithms.		
5.		Bellman-ford algorithm.		
×6.		shortest paths in DAGES. 1		
Ă.		Dynamic programming + Matrix ch - Multiplica	ann Hann	
8.		Longest common subsequence.	6	
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, W.		Knopsack). Subset sum Trovielling Salesman problem.	6	
12.		Travelling Salesman problem.	-:	
18.		All pairs shortest path - Floyd	8	
		Warshall.		
140		NP Completeness . (Not reg for gale)	- 8	
150		+ problems on Np completeness a		
	<u> </u>			

atlantis Time and space analysis Dat WNW.gatenotes.m Introduction to asymptotic notations = problem program in c 1215 A 1 ..... 14-1 analysis of an algorithm by - (1) Time (less time) (1) Memory ( use memory) (i) Big (Oh) (): cg(n) 古个 ex:  $f(n) = 3n + 2, g(n) = \eta$ f(m) = O(g(m))f(m) < (g(m), (>0, no))  $\Rightarrow_{\eta}$ 50 3n+2 << CM.  $f(n) \leq cg(n)$ c=4nzno  $c > 0, n_0 > 1$ 37+254n f(n) = Og(n) $(S_0, f(m) = 3m + 2 - 1, g(m) = n$ f(n) = O(g(n)) = O(n)upperc -> always go for least n  $q(n) = \widehat{m}$ bound.  $\eta^{4}$ here least upper pound is 7. -m m m

atlantis and space inne Date Page a star a st **Your Personal Exams** üis Big Omega S: for L ex? f(m) = 3m + 2,  $g(m) = \eta$ 1 Cg(m) f(n) = lg(n) $f(n) \geq C\tilde{g}(n)$ . no 37+22 (7) m C=1. mb>1  $f(m) \geq Cg(m), m \geq m$  $\Rightarrow$  3n+2=S(n)(>0, no>1 f(m) = R(m) Lowers Ŧ take always closest 1 bound logn here closest bound is - m (loglogn) (i)) Big theta O; Cfa(m) fen) (c)gen) 七个  $f(m) = \Theta(q(m))$ Gg(n)≤f(n)≤c2gen) E, C2>0 no nzmo カロシリ  $3n^2 + n + 1 = \Theta(n^2)$  (Always take leading term)  $3n^{3} + n^{2} = \Theta(n^{3})$ 

atlantis Intervented. Your Personal Exams G OA <  $\mathbb{N}$ Avercage case Best case Worst case tore time or the Upper bound  $(\theta)$ Average case is used when worst care and best care is some-both are some. antray 572369 m this arrive by linear 20 1) 9 then find 21 exis In Bast case time = R(1) - (found aut in 1st mdex) In worst care time = O(n) - ( if the size of anny n') for then found out & in nth possition) In average care time taken =  $\Theta(m_2) = \Theta(m)$ Time complexity Analysis of itenative programs > Algorithm are two types = Algo . iterrafive) Recursive A() A(n) ξif( for 1=1 ton  $A(m_2)$ max (arb) Any program that can be to witten using Iterrahion.

atlantis Date Page Your Personal Exan > Any program that can be written using recursion could be written using itercation. Any that not contain iteration and Recursion Aprogram no iterration and pecuring inside the > If there is program you need not wonny about the time. for such program time - O(1). l'errative program Some Example of A A A() A() lnt i inti, for (i=1 to n) for (i=1ton)~ printf("ravi"); · for (i=1 ton print (novi) -> JPme complexity O(n). (travi exe printed n times) -> Time complexity 30  $O(n^2)$ A( 901,S=1) 15 21 ... 21 While (S<=m) it+; S=S+1Sum pf("travi"); natural no, Ş ζ K =O(Vm  $\rightarrow$  Time compuxity =  $O(\sqrt{n})$ . 6

atlantis 4 AC) AL) K= 1 m 1 for (i=1; 12.<=m; i++) pf ( ( pavi"). Ş >Time complexity - 0 (vm). 5 A()  $\Xi$  intini, k, m; for (l=1; i<= n; i++) { for(j=1) j (=1; j++) { fur (K=1; K <= 100; K++) { pf( "Ravi"); 2 Q 3-1=2 i=4 1=3  $\hat{i} = 1$ j=4 times j= 2 times J=3 J= 1 times K= 3×100 K= 2x 100 homes K=4×100 K= 100 times  $\vec{s} = \eta$ j=n times K= n #100 b 100 + 200 2×100 + 3×100 + 4×100 +5 ×100 + -- + >> ×100 (1+2+3+4+5+···+か) 100  $\frac{-100}{(n^{2}+n)} \xrightarrow{2} = 100 \text{ (m^{2}+n)} \xrightarrow{2} = 100 \text{ (m^{2}+n)}$ 

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atlantis Date Page Your Personal Exams G A() E Int 1, 1, K, B; forc(i=1; i<=n; i++) forc (j=1; j <= i2; j++) for ( K=1; K= 1/2; K++) Pf (c( ravi"); E pol 223 1=1 1=2j=41=4 1=3 1=5 J=9 ĵ=16 J=25 himes J=1 Hme K= m/2 \*1 K= m/2 \*4 K= m/2 \* 16 K= m/2 \* 16 K= m/2 \* 25 i = n  $j = n^2 + i mes$   $K = n_2 + n^2$  $= \frac{m_{2} + m_{2} * 1 + m_{2} * 9 + m_{2} * 16 + m_{2} * 25 + - + m_{2} * m_{2}}{m_{2} * 16 + m_{2} * 25 + - + m_{2} * m_{2}}$  $\rightarrow \frac{1}{2} (1+2^2+3^2+4^2+\cdots+m^2)$ AP.  $f(n) = n^{K} + n^{K-1} \cdots = O(n^{K})$ m/2  $\left(\frac{\sqrt{m(m+1)}}{2m+1}\right)^{4}$  $\rightarrow \frac{1}{12} \eta(n^2 + \eta) (2n + 1)$ -) /1n(2m<sup>2</sup> + n2 + 2n2 + n) -) Vin (2nt+3n2+n) -) Time computity -' O(nt).

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+lantis 10 (10g 10m) A()  $\begin{cases} A(leg_{\eta}) \\ 3(leg_{\eta}) \\ 3(leg_{\eta}) \\ \vdots \\ 1 = i \frac{\pi}{2} \end{cases}$ pf (travi);  $\frac{=1,2,4,8,\ldots,m}{2^{2},2^{1},2^{2},2^{3},\ldots,2^{K}}$ 5-1 32 2K=7 K= Log n Time complexity or time taken to execute = O(log n) (8)A()5 int isik; fore (i=m/2; i<=n; i++) - Indepent 100p - m/2 fore (j=1; j<=m/2; i++) - m/2 Por (K=1; KK=n; K=K+2) - 10gm pf("ravi); > m/2 \* 1/2 \* log\_m  $\frac{n}{2}\log_2 n \rightarrow O(n^2\log_2 n)$  Time complexity 9 Nº For to-Al) Eint i, j, K;  $for((i=n/2; i<=n; i+t) - n/2 - for((i=1; i<=n; i=2 + i) - log_2n.$  $forc(K=1), K <= n; K = K * 2) - log_2 n$  pf("ravi");- C(n(log n) -> O(n(log n)2) < Time complexity (removed (onstants)

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atlantis Date\_\_\_ Your Personal Exams (10) assume n >2 A() <sup>É</sup> while(n>1) 22 5 n= m/2 n=2K 10gzn  $K = \log_2 \eta$ log 5m Time complexity - O (10g 2). A A()  $\frac{2}{3} \frac{forc}{j=1; j<=n; j+1} = \frac{2}{3} \frac{1}{3} \frac{$  $\begin{array}{c} \rightarrow & i=1 \\ j=1 \text{ to } m \neq \text{orelignes} & j=1 \text{ to } m \\ & & & & \\ \end{array}$ 1=3 i = Kj=1ton j=1100 ... (Ilavi-primled) - n times M/K Hmes m/3 times  $i = \eta$ j=1 to m 1 Kmes (Rowi printed) n + m/2 + m/3 + n/4 + - + m/k + - + m/mapro) (1+1/2+1/3+1/4+···+m)/m) -> n 10gm > time comprexity - O(nign). 11.16

atlantis Date A() Ę But  $n = 2^{2K}$ ; for (l=1; i < = n; i + +) (n)Ĵ=2 while (j < = n) $\frac{\xi}{(j^2 - j^2)}$ pf( <sup>cl</sup> Rovi"); . 1 K=2 K=3 K=1n=4 $\beta=2,4$  $m = 2^{4}$  $j = 2^{4} + 2^{2} + 2^{4}$  $n = 2^{8}$  $j = 2^{2}, 2^{2}, 2^{4}, 2^{8}$ n + 2 times n + 3 hmis 1 n+ 4 times  $\frac{n=2^{2k}}{\log n}=2$ M\*(K+1) 2K m (Log Log m +1) 1-14) C4 Time complexity of this is algorithm - O (nloglogn) K = log log of 

atlantis Date Page **Your Personal Exam** • Time Complexity Anabycis of recursive program X A(n)By-using Been-Substitution { pf (m>1) ~ method you we can find return (A(m-1)); the time complexity ut Z any Atgo that trecution program T(m) = 1 + T(m-1); m>1n=1 21 Back Substitution) -- (method) T(m) = 1 + T(m-1)6 T(m-1) = 1 + T(m-2)(2) T(n-2) = 1 + T(n-3)3 put equ (2 4(3) into equ (1) = T(m) = 1 + 1 + T(m-2)= 1 + 1 + 1 + T(m - 3)= 3 + t(n-3)= K + T (m-k) (16 1 set of ) h-K=1 =(n-1) + T (n-(n-1))K=n-1 . = (n - 1) + T(1) $= \gamma - 1 + 1$  $= \eta$ T(n) = O(n) + Time complexity.

atlantis Date. 1187 2 T(m) = m + T(m-1) ; m > 1= 1 ; n=1 ford Time complexity By Juring back Substitution) = method. T(m) = n + T(m-1)T(m-1) = (m-1) + T(m-2) - (1)T(n-2) = (n-2) + T(n-3) - (11)(TIM) T wars T T(m) = n + (n-1) + T(m-2)= m + (m-1) + (m-2) + T(m-3).  $= n + (n-1) + (n-2) + \dots + (n-k) + T(n-(k+1)).$ m - (k+1) = 1n - k - 1 = 1K = n - 2= n + (n-1) + (m-2) + - - + (n - (m-2)) + T(1)= n + (n - 1) + (n - 2) + - + 2 + 1-- , A.P  $= n(n+1) = n^{2} + n (nerre most significant$  $2 2 tenm n^{2})$ So, time complexity - O(n2). (3) Recursion thee method = (1-1)  $T(m) = 2T(m/2) + C_{j}m > 1$ = ( m = 1find time complexity using recursion tree method -T(m) = 2T(m/2) + (.

atlantis Date . Page Your Personal Exams T(m) T(l) = T(m/m)C T(1/2) J(n/2 3.6 (m/s (m/s) T(MA' 7/9) -46 T(m/3) T(m/3) TIMA TIMAS T(m/3) T(m/3) T(m(2) T(m/2) C Ċ C C C C 80 T(1) T(1) T(1) • 6.0 nc 1 = (11 - 1 - 1 > C+2C+2C+8C+-.+nc Let C  $(1+2+4+8+\cdots+m)$ m=2K n.  $C(2^{\circ}+2^{i}+2^{2}+2^{3}+-+2^{k})=-6p$ (2K+1-1) (2-1)  $C(2^{K+1}-1)$ Minth Will (2K-2-1) (2m-1) () (n), -Time complexity

atlantis  $(\overline{4})$ T(m) = 2 T(m/2) + m; m/21n = 1-1 find time complexity using Recurcing tree method= WOTCK dome each level n (total workdome)  $\tilde{\mathbf{M}}$ J(m) T(m/2) T(m/2) -n $n_{12}$ 2T(M/4) 2T(m/4) -2T(m/4) 2T(m/4)  $\sim$ 1/4 n/4  $\xrightarrow{\rightarrow} \mathcal{N}_{50} \xrightarrow{\rightarrow} \mathcal{N}_{21} \xrightarrow{\rightarrow} \mathcal{N}_{22} \xrightarrow{\rightarrow} \mathcal{N}_{23} \xrightarrow{\rightarrow} \cdots \xrightarrow{\rightarrow} \mathcal{N}_{2k}$ In=2xborg K=logn  $\frac{\eta_{20}}{1} + \frac{\eta_{21}}{1} + \frac{\eta_{22}}{1} + \frac{\eta_{13}}{13} + - - + \frac{\eta_{2K}}{13}$ 1/20 + 1/21 + 1/22 + 1/23 + - - + 1/2K)  $\sim$ (K+1)  $\gamma$ n (10gn+1)  $\rightarrow$ 50, here. Time complexity is - O (mlogn) 101 5 UCI

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atlantis Date Page **Your Personal Exan** Masteri te uni May-10 Solve Ctome complexity vatures functions to analyse time complexity Comparing Ø) (ex-)  $\frac{2}{2}$  $2^{n}$ 10g m logz n 10g 2 2/0gm  $\gamma$ 210gm put, n=2128 IY. 2128 2 10g 2128 \*12 117 11 1 2" is largete than n 50, exnign n xn 7 log m 3 109 20 16 familie function m<sup>2</sup> is grater than logn (10gm)<sup>100</sup> (ex\_2 -> log m 100 g log log n  $n=2^{10}$ 100 log log 2210 210 1024 1000 n is larger than 1997.

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atlantis Dal Pac mlog (ex-4) nlogn  $\rightarrow \log(n^{\log n})$ → 10g (n. 10gn)  $\rightarrow \log n + \log \log n$ . -> logn logn n=228 128 +7 -> 128 + 128  $\rightarrow$ nlogn > n logn ex-5 log log n log log log no 1 10g log  $m = 2^{10}$ 1/2+10 109 10 5 = 3.5 > loglogn V logn (2x-6 1-^ 2 log 7 n -> log n > log nogn > lognlogn. 1 >vn logn  $\rightarrow \sqrt{n}$ -> logn 1 . -> 1/2 logm -> logælogn n=2"8 DOROCLANS -> 1/2×128

atlantis Date Page **Your Personal Exan** ex-7) n<sup>3</sup> 0<n<10000 f(m) = n m> 16000 g(m) = 6<7<100 m m3 m>100 100-9999 1000 - - -00 0-99 m3 η3 m f(m) 1 TPO <u>m<sup>3</sup></u> (D)3 gm m f(m) = O(g(m))So, g(m) f(m) $f_2 = n^{3/2}, f_3 = n \log r, f_4 = n \log r$  $f_1 = 2^m$ £X-8 22 m3/2 mlogn nlogn m10g2 3/219 3) logn + log logn 10gn 10gn  $n = 2^{12.8}$ 2128 -> 3/2 +128 >128+7 -> 128 +128  $f_1 \rangle f_4 \rangle f_2$ fz 6) -> This is how functions are compared ί., 10

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(10gm) 7 7 10g2m => logn xlogn + log logn · Masterrs theorem = ( to hand time complexity of recursion program easily)  $T(m) = \alpha T(m/b) + \Theta(mK \log^{p} m)$   $\alpha \geq 1, b \geq 1, K \geq 0 \text{ and } p \text{ is real Number c.}$ i) if  $a > b^{K}$ , then  $T(m) = \Theta(n^{\log 6})$ ii if  $a = b^{K}$ a) if P > -1, then  $T(m) = \Theta(n^{\log_{10}} \log^{P+1} n)$ b) if P= -1, then T(n) = O (nogo loglogn)  $9 if P < -1 ; then T(n) = \Theta(n^{1095})$ ill) if a <bx. a) if  $p \ge 0$ ; then  $T(n) = \Theta(n^k \log^p n)$ b) if  $p \le 0$ ; then  $T(n) = \Theta(n^k)$ . lex-1]  $T(m) = 3T(m/2) + m^2;$ after compare with Martens equation = here a=3, b=2, K=2, P=0 $\begin{array}{c|c} \alpha & \beta k \\ 11 & 11 \\ 3 & \langle 2^2 \\ \end{array}$ iii) a)  $\frac{T(n) = \Theta(n^2 \log^2 n)}{|T(n) = \Theta(n^2)}$ 

n fint = (mpi) atlantis when buy of allera ) Date \_\_\_\_\_ Page \_  $T(m) = 4T(n/2) + n^2$ Ex-2 After Compare with Masters equation, a=4, b=2, K=2, P=0a=4  $b^{k}=2^{2}$  $a = b^{K}$  $\hat{v} \rightarrow \alpha$  $\begin{array}{c} |i\rangle \rightarrow \alpha \\ \hline T(m) = \theta \left( n^{\log 4} \log^{0+1} \right) \\ = \theta \left( n^{2} \log n \right) \end{array}$ Ex-3  $T(m) = (T(m/2) + m^2)$ > After compate with masters levation - $(x_{1}, a=1, b=2, k=2, p=0)$  $\alpha = 1 \xrightarrow{b^{k}} \xrightarrow{b^{k}} 4$ Ta < by  $|\hat{I}\rangle \rightarrow T(m) = \Theta(m^{k}|q|^{n})$  $= \Theta(m^2)$ EX-B T(m) = 2<sup>n</sup> T(m/2) + m<sup>n</sup> 1) In this case master theorem can't be apply.

atlantis Dat Page Your Personal Exams Ex-5  $\alpha = 16, b = 9, K = 1, P = 0, S = D$  $a = 16 > b^{k} = 4$ (i)  $T(m) = \Theta(m^{109}b)$  (a < iii  $= \Theta(m^2)$  $E_{n-6} = 2T(m/2) + n \log n \cdot \frac{1}{2}$  $\rightarrow \alpha \equiv 2, b = 2, K = 1, p = 1$ a=2 = bK=2 a=by ....  $\frac{11}{T(m)} = \frac{1}{2} \left( \frac{1}{2} \log^{2} \frac{1$ = (0) 10533 Ex-7  $T(n) = 2T(N_2) + \frac{n}{\log n}$  $= 2T(\gamma_2) + \eta \log \eta$ .  $\rightarrow \alpha = 2, b = 2, k = 1, P = -1$ a = bK $\frac{1}{1} = \Theta(n^{\log b} \log \log n)$ = O (n log logn)

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atlantis Dat Your Personal Exam Ex-8  $T(m) = 2T(m/4) + 3^{0.51}$ .  $\rightarrow a=2, b=4, k=0.5), f=0$ a=2 < b=4"15  $\frac{1}{1} \xrightarrow{(n)} = \Theta(n^{(n)})$   $\frac{1}{1} \xrightarrow{(n)} = \Theta(n^{(n)})$ Ex-9 T(n) = 0.5 T(n/2) + 1/2 X $\rightarrow q = 0.5$ , b = 2, K = -1, P = 0 (not possible using a=0.5  $b^{\mu}=2=\frac{1}{2}=0.5$  masters theorem) WELL a should be Taxil  $\frac{110}{100} = \phi(n^{195}/1000) = \phi(n^{195}/1000)$  $[E_{X-10}] T(m) = 6T(m/3) + n^2 log m.$  $\Rightarrow$  here,  $\alpha = 6$ , b = 3, K = 2, P = 1 $T(m) = \Theta(m^{K} \log^{p} m)$  $= \Theta(m^{2} \log m)$ 111) a)

atlantis Your Personal Exam Ex-11 T(n) = 64 + (m/8) (=)n<sup>2</sup> log m. X -> here we can<sup>2</sup>t apply masters theorem. # for "-" sign. Ad Ir Ex-12  $T(m) = \mp T(m/s) + m^2$ mit- G a=7, b=3, K=2, P=0  $\rightarrow$ act (m)  $(\tilde{n})$   $(\eta) = \Theta(\eta^2)$ 1 - 1 7  $E_{N-13}$  T(n) = 4T(n/2) + log n. → a=4, b=2, K=0, P=1 here, [a>bK] 2 GOT LI  $\frac{1}{1} \quad T(m) = \Theta \left(m^{\log s}\right) m^{-1}$ 151-5  $= \Theta(m^2)$ EX-14  $T(m) = \sqrt{2} T(m/2) + \log \eta$ a=v2, b=2, K=0, P=1 here, [a]bk]  $i \rightarrow \pi m = 0 (n^{\log 2})$  $= \Theta \left( \gamma^{\log 2} \right)$  $= \theta(\overline{m})$ 

atlantis Dat **Your Personal Exams** Ex-15  $T(m) = 2T(m/2) + \sqrt{2}$ > n=2, b=2, K=1/2, P=0 here, a) bK  $\frac{1}{1} - T(m) = \Theta(m^{\log_{2}})$  $= \Theta(m^{\log_{2}})$  $T(m) = \Theta(m)$ Ex-16 T(m) = 3T(m/2) + m. 01=3, b=2, K=1, P=0here, ALBK i)  $T(m) = \Theta(m^{\log 3})$ Ex-17  $T(m) = 3T(m/3) + \sqrt{n}.$ -) n=3, b=3, K=K2, P=0 here, azzki i  $T(m) = O(n^{\log 3})$ = O(n).

atlantis Dat Ex-18 T(m) = 4T(m/2) + cm. - malli a=1, b=2, K=1, P=0here, gJLK (nlog4) 1 T(n) = 02 NI L Ex-19 T(m) = 3T(m/4) + (nlogm).7 G=3, b=1, K=1, P=1 la< bk 11) () AN T(m)= O (nK) logm  $= O(n^{1} \log^{1} n)$  $= O(n \log n)$ 

atlantis Date Your Personal Exam Analysis space complexity of Herrabive and recursive Algo iterative recursive. Space Complexity for Herative program D Algo (A, 1, m) (A) (A) (A) (A) [int i, j=10; - (2) for(i=1 toj) int ijv......(1) for (i=1 ton) A(f) = 0; $\frac{A[i]=0}{3}$ > space complexity = O(1) -> space complexity = O(1) 2 Algo (Asim) Int in (n+1) Erreat B[m] j -> space complexity - O(m) forc (i=1 to m) BCIJ= AFIJ; 3 Algo (A, 1, m) - 2 (reat B (m, m) -(n<sup>2</sup>+2) inti, 1/2 - 2 fore (i=1 ton) For (i=1 ton) - here space complexity - O(2) B[ij] = A[i]

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atlantis Dat our Personal Exams G · Space complexity of recursive (Algorithm) program > When the agreed and program no. of statement less incide the program then use tree method. <u>ex-</u>  $\frac{A(n)}{\xi} = \frac{(n+1)}{(n+1)}$ -(n+1)<u>{</u> A(m-1); 3 Pf(n); Space complexity = O(n) 1.1.1.6 (-jA(3) 1→ 4 A (2) \$(3) time complexity = recursive equation n=0 T(m) = T(m-1) + 1 ; m > 1An 0(2) P(1) (A(6) T(n-1) = T(n-2)+1 output= 1 2 3 T(m-2) = T(m-3) + 1T(n) = T(n-3) + 3for A13) function called - 4 homes. T(m) = T(m-K) + Kfor Arn) function called  $= T(n-n) + \Im$ - n fimes. =  $T(0) + \eta$ -> space complexity is depth  $= 1+\eta$  $T(m) = 1 + \eta$ of the tree ALOY =0(n). All Kξ  $\eta - (\eta + 1) K$ . -O(kn)

atlantis Date Your Personal Exams G (find Time & space complexity) 2 ex-(2+1) A(m)ξ if (のス1) ξ A(ng-1); 1, Pf(m); 3. A-(m-1); A(4) n = \$ (++1) Ala A(3) P(4) Á(8) 16 Any P(3) A(2) M2) A(2) P(3) p(1) A(1). A(1) P(1) A(1) A(1) P(1) A(1). ALY PLEY ACY Aci Ales ALOPRIJACALOS PLY Ales) ( ) Ales ALOPRIJACALOS PLY Ales) ( ) Ales PLY MO) PLY A(1) A(0) PLY A(0) NI Ale Aro) chere Complexity = O(nti) O(m)outout 1 2 2 V 4+1-1 2 (A-(9) 31 90 Emes finction can ) 2<sup>2+1</sup> 3+1 A(3) . 2 An 21+1 A(I) for n ranule function called CODADI Am m+1. . ١ Scanned by CamScanner

) Date Page Time complexity lecurrive equation =  $T(m) = \mathfrak{gr}(m-1) + 1 + T(m-1)$ = 2T(m-1)+1 ; n > 1= 1 ; n=0  $\frac{T(m) = 2T(m-1) + 1 - (n)}{T(m-1) = 2T(m-2) + 1 - (n)}$ T(m-2) = 2T(m-3) + 1 - (11)T(m) = 2(2T(m-2)+1) + 1= 2.2 T(m-2) + 2 + 1  $= 2^{2} (2!T(m-3)+1) + 2 + 1$ = 2<sup>3</sup> t(m-3) + 2<sup>2</sup> + 2<sup>1</sup> + 2<sup>0</sup>  $= 2^{K} T(n-k) + 2^{k-1} + 2^{k-2} + \cdots + 1$  $= 2^{n} T(0) + 2^{n-1} + 2^{n-2} + \cdots + 1$ n-k=0 $k=\eta$  $= 2^{m} \cdot 1 + 2^{m-1} + 2^{m-2} + \cdots + 1$  $= 2^{m} + 2^{m-1} + 2^{m-2} + \cdots + 2^{e} - Gp$  $= 1(2^{n+1})$ 2-1 = 2n+1-1  $= O(2^{m+1})$ T(m) = O(2^m) . (Time complexity)



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atlantis Soroting Techniques Date Page Whin gatenotes. In ersonal Exam • Insertion sout algorithm and analysis -Insertion - sort (A) forc (j=2 to A. length) mher // insent A[] into stoked sequence A[[....]]] Key= A[j] ا - ل = ۱ while (1) and A[i] >> Keg) { A[[+]= A[]. 1=1-1 3 "> A []+1) = Key 3 (1 < 1. (1) & - (1) Key=9 5 Workig Providure = +1 +2 3 4 5 6 2 Annay <u>4</u> 5 Key = 6 6 (1)2 2 5 3 Key=6 E) 5 9 .7 2 6 A. (3)the 2 Key=5 5 4 2 5 6 9 7 Á. 4. t 4€ 75 Key=7 (4 ર 5 6 9 7 4.5 .4 4 3 5 (shorted) (5) 2 5 16 9 7 11 -+ (+++++++ = (2))

2 million of the Dat Time complicity in worst case = 0 (m2) + +++ Hhen 3 2 >revenued attray Compations movement mdrex = 2 = 2(1)Ŧ 2 4 = 2(2)2 + 2 3 -= 6 = 2(3)3 4 4 3 = (8 = 2A)4 5 (n-1) = 2(n-1)m-1) + ne  $T(m)=2(1)+2(2)+2(3)+2(4)+\cdots+2(m-1)$  $1+2+3+4+\cdots+(n-1)$  (A·P)  $\gamma(m+1)$ 5 2 (n-1) (n-1+1) n-n  $\overline{T(m)} = O(m^2)$ • Time Complexity in Best case = O(m) . (m). 2, 23 4 > when anney or already sonted. Index Computitions movement ¢ e \* + : 1.  $O^{\circ}$ - 1 2 2100 3 + 0 21 31 4 + 0  $z \mid$ æ + 0 1 n 21  $T(m) = 1 + 1 + 1 + 1 + \dots + 1 = S(m-1) = R(m).$ 

atlantis Date • Space complexity = O(1) (main in the second (need only 3 variable) When we need constant space to sort any given list, such algorical Implace Algo. yiven list So, Incertion sprit also called Inplace Algo. ai movement When wed Comparisons  $= 0(\hat{m}) \cdot (T \cdot c)$ Binany Search 2) O (log m) ð(ŋ = O(m)0(2) double (J.C) Loked tist Merrge Sorrt algorithmand analysis MERGE (A, P, q, r) IMenge procedure]  $m_1 = q - p + 1;$ n2= r-19; Let I [1. - n+1] and R [1 to mit] be new annays for (i=1ton)  $\bot [i] = A[P+i-1]$ fore (j=1 to m2) RG) = A[9+j]; $f(m_1+1) = \infty;$  $R(m_2+1) = \infty;$ i = 1, j = 1;

atlantis Date Page our sonal Exams for (K=p to r)  $if(lci) \leq R[j])$ A[k] = L[i]8 <u>i=i+1;</u> else A[k] = R[P]· j= j+1; 4 9+1 P ۱ 2 ex 3 4 2 4. 6 7 A .5 8 O(m).2 41619 R 5 平 0 78 4. 5 4 2 3 78 67 8 0(n+n) - 0(n 4 9 A 5 2 Sorted wing (menge sout) Total time taken by metrge stat = O(n). o(m Span complexi 1+9-D = 10 is athe called - The res > merge provigen out of place photo Merge procigin called > Menge procedure is only called out of place procedure. -11 -Se a (ina) Vor ( That )

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atlantis Da [Marge-sort a." 1 merrge-sort (A, P, m) --7(m) ş if P<r ſſ 9 = ] (P+m)/2 1 T(m/2) mercqe-sort (A, P, 9) T(m/2) Sort (A, 9+1, r) mengemerge (A, P, 9, p) nin Ş 1.1-2 RX: 3 4 5 6 ŝ 6 9 5 0 8 2 A 170 1 MS (1,6) 14 2 MS(4,6) M(1,3,6) MS (1,3) 5)Ami(5,6) MS[1,2) MS(3 M(1,23) MS/A M (4,5,6 M(4, 4, 5 MS(4,9 MS (5,5 M(1, 1,2 Ms(1,1) MS(2 80 6  $(\bigcirc)$ (9) 9 ... 0,2,8 56 9 2,5,6,8,9 0, -> Sorched

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Space complexity required by the marge sort - Om 4) 8, B. V. K. B 3) XXXXXX 2) \$ 16 6 - . 4 level n - (120gm]+1) lives. size of stain = ([logn] +1) K O(K(logn)) = O(logn) 30, total span Requiried to compute mane sont for marige procedure - D(m) stack - O (logn)  $O(m) + O(\log m)$ = O(m)I'me computing required by the merge cont - O(mign T(m) = 2 + T(m/2) + O(m) T(m) = 2 + T(m/2) + O(m) T(m) = 0 T(m) = bK $\pi(m) = \Theta\left(m^{\log_2} \log^{O+1}\right)$ = 0 (n 10g n)

Dat 8-1 (2- Way mingeing) Given melements, marge them into one sourced menge procedure that is time complexity wing Q(m) : フ 10g 8 8. Olm log 4 4 on 092 3 Clements 5 5 1 11 ١ × 1 Totas time = 0 (m) \* 0(logn)  $= 10 (m \log m)$ 12.0 Tr M O(m) > WORK done each level no. of levels -> o(10gm) 03-2 Griven logn souted lists of size. Mingin what is the total time prequired to metige them into one single list n-(Niogn) logn (09/09 D) (togn 3/10gm 7 iolm) level total climbing - liglog of logn lener 1092 27/1097 n/logn m/logn o Yingn Wingn total element logn \* hogx = n element each uver. time tomp Time complexity = O(nloglogn)

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atlantis MELST Your Personal Exams 8-3. Then what is the time taken to sort them agb aan n.10 ( a) = O(Logn) × O(m) unes (1090) 2 .0 (m216gm 189 0(m) × 0(m) + 0(m) 2 0(m) in ... 1092 n  $\gamma$ 1. 1. 1. V. m total time compreptity = 0 (m log m). 8-4 Divide and Conquer a(1) Merrge south lines total time taken to merge 2 m and 3 m, n two rotited Wit O(m + m)(compare and copy Algo 2 way menging) sound in 15 8 9 4 40 47 20 30 12 17 What will be the order of elements affer 2nd pass -MISICE ( = (Rougers) in

atlantis Dat Pag xams G 40.30 12 17 4 8.1.9. 20 41 15-30 40) 12 17) Ŷ (20 47) 8-15) 4 12,17 40 30 9 8, 15, 20, 17 2nd pary this > After order we get the Hidar 1011 2 • 0 ----4.61 .2 4 (3 .2 ð 60 0 7 2 C 3 -30 ς. 2 1.10 0 . 5 6 2 ÷ \_ 4 lei XS 4 1 4 01 2 44 10 13 1 C.A. : )1 1 1 .

atlantis Buick Sort algorithm = > For Smaller no of Input, Buick sout o trun faster compare to merge sort. Buick Sort and menge sort Both follow divide and conquere method. · partition Algorithm = Time taken by the partioning algorithm = O(n). Texe 1 3 8. 2. 4 7 0 5 9. б. ¢ 8 2 4 9 6 5 Û [8. 9. 4 <del>]</del> 2 .5 Ô 6 Quick Soret 0 (Ŧ 9 6 5 γ 4 3 6 D 2 (7) 9 \$75 PJ. 21 ex10 5 12 4 9 8 19 2 6 A 13 10 PARTION (A, P, P) n=AF) i = P - 1;for (j=p to ~-1) 0 exchange ALi) with ALI)

atlantis If(A[i],x)i=it1; WARD MONTH exchange A [i] with A[i] er in Exchang A[P+1] with AFr) tuhing i+1; 2 1 1 1 1 1 1 (4-1) ((4+1) 1 Ot QUICKSORT (A, P, m) - T(m) (P で 5 > P. Zamer Carre Carre Store ?+ ( +<r) n.M 9= PARTITION (A,P,m); -O(m)  $\mathcal{B}$  ULKSORT (A, P, 9-1); -  $\mathcal{D}(\gamma/2)$ -TIm(L) BUICKSORT (A; P, 4+1); un best only C L exa 5 7 4 123 4)5 (1,7) BS (1,7) 1,7) BS (1,3) BS(5,7) 9= 0 OS(5,4) OS(6,7) P(5,7) BS(UI) BS(3,3) P(1,3) (5) 9= (2)  $P(6,7) \xrightarrow{BS(6,6)} \xrightarrow{BS(6,7)} \xrightarrow{BS(6,7)} \xrightarrow{AS(6,7)} \xrightarrow{$ 9 1 ) -Call = 13 function total

Date Page > no of levels in the tree equals to the no of stack entries trequired.  $(\mathcal{T})$ (m/2) (n/2)M4 .... m/4 1 stack M4 m best case Span complexity = 0 (10gm) 6.0 (in cone if It is balanced) In worst case space complexity = O(n) (Unbalanued) A Antitatet 2-2-0 m-4 In best case time complexity = O(nlogn) T(m) = 2 + T(mh) + O(m)using masters theorem TImj = O (mlogn). = SC (mlogn) worst care time complexity = O(m2) back supphilien 1 5 6 7 10 T(m) = T(m-1) + O(m)30 = T(m-1) + (m) [when  $\frac{9}{11\pi ay}$  in ascending =  $T(m-2) + ((m-1) + (m) = 0(\pi)$  $= \tau(m-i) + Cm$ = T(m-3) + C(m-2) + C(m-1) + Cm

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Clandwi  $= c + c_2 + c_3 + \dots + c_m = c(1+2+\dots - m)$ = n(n+1)T(m) := O(m)5 92 Almert and 1 a basis -> Even input in assending order or desending Order to, time complexity is = 0(m2). and the Up all are same then time complexity = O(n2) > best and workit Combination -... - 0(m) O(m-1) - O(m)(m-2) (m-2)  $T(m) = O(m) + O(m) + 2 T (\frac{m-2}{2})$  $\leq 20(m) + T(n/2)$  $= \Theta(n \log n)$ Suestion - 1 The median of n elements can be found in o(m) time , which one of the following is contract about complexity of quick sont, in which median is soluted as pivot , ? to found median = O(m)  $\pi eplan = O(1)$ parhihim = O(m)T(m) = O(m) + O(1) + O(m) + 2 T(m/2) - m/2 + m/2Wing master theorem, T(n)=O(mlogn)

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atlantis Date Page sonal Exan 617 ( C.S. P. ( 10) Suestion - O In quick sont, for conting 'n' elements, the (N/4) the smallest element is selected as point pivot using oin time algorithm. what is the worst space complexity of quick cont. O(m)3n/4 mia -pantion T(m) = O(m) + O(1) + O(m) + T(m/4) + T(3m/4)1:3 1:9 1:95 1:95 T(m) = O(m) + T(m/4) + T(3m/4) = O(mlogn).O (nlogn Buestion - 3 using Quick sort on an algorithm, given I/p 1,2,3,... n Time taken TI )) T2 what is the trelation chip between T, &T2. either elements are arrending order or densending order on all equal then this care time taken 0(m2)  $T_1 = T_2$ 3+ (m) + in 11

Dat Page Buestion)- (1) parihon algo which take O(n) hme are spliting the problem Into two part We Asn what is time Complexity. then MS)+T(4) O(n)T(m) 7(m) ++(1%) O(m)Introduction to - HEAPS: 0 incent Doloto min Findmin search Unsorted O(n)0(1) (O(n) O(m)O(logz)  $\mathcal{O}(I)$ O(m)O(m)Sonted O(m)O(n)O(m):1 0(1) Unsorated linked (ist O(logm) 0(1) O(logn) min heap Time complexil -> heap is any datastructure which used optimile some of the operation heap min heap max heap. heap sont algorithm. - ming heap we \_mplement com

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atlantis Date\_ Page Your Personal Exams Gu > Heap could implement as a binainy true, or 2-any the tree; ... n-any tree an > Eveny heap is submost complete binarry tree almost complete B.T. Complete B.T. 294.314 ٢ tont. 6 MIRLORA Max-heap: hab 100 -> all the elements in the ŹØ reat should be grater than leaf. Min-heap : S revi minimum element will (10)20 prevent & in the root. (100 (200

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Dat Page Storce complete binary tree in a max heap = annay = + (00) 1×2=2 1×2+1=3 ON) ---(10) 20 2×2 2×2+1 2×2 13,6 annay 100 10 45 (A WORT 20 ۱ 2 4 d Stawe  $teft child(i) = 2\chi_1^{\circ}$ light "(i) = 2xi+1.perunt (1) = [1/2] > if the array in assending onder -, then it is min heap 10/12 113 8 ( Koot element adways less than it child) (12) (10 14 (13 -> if the attray in decending order - then it is already max near 19 13, 12 10,8 ( real element 3000 always greater than its child (12) (10

atlantis Date Page Storial ment ATITAL heap Lize Annay length 6.7 4.5 12,16,13,10,8,14  $\widehat{}$ 25. 1 7 03 7 (Mar heap) 7 25, 14, 16, 13, 10, 8, 12 2) 1 +. 25, 14, 13, 16, 10, 8, 12 3 2 7 25, 14, 12, 13, 10, 8, 16 A 5 (morth) 5 010 I 19, 13, 12, 10, 8 5 5 (MAXH) N 14, 12, 13, 7, 10 6 12 max w 5 S (F) 14,13,8,12,10 14,13,12,8,10 5 (Mary 5 ରି S 789 10 11 12 4 6 2 13 40.17/13 10 2 70 F 2 Ø (28 (1) 25) 3 2 18 2 14 12 6 5 4 8 IN 12 10 (89)! ---2 3 2 90<70 3 follow 40 19 8 Loch in MAA 13 ×(14 propenty 5 6 7 2 17 12 10) 12 16, 16 8 6 11

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Date Pageyour lome phopenhes of complete binany trice -= hight of a tree = hight of root. -hight : (0) Ht(+)=1 h(2)H(T) = 2-h(1) -h(0) 111 1 191 h(3)H(T) = 3-h(2) 7-h(1) -h(0)2 3: 4 · · · h Hight  $15 31 \cdot (2-1)$ 3 チー more norot • maxAnode in complete binany tree = (2-1) (h > hight) · n'nodes inside à complete or almost complete binany tree, what is then hight of tree = 10gn]

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atlantis Date Page Your Personal Exams - hight of any binary heap is = 1 log m n-) no of node mide of tree) 1) to fil 1.1 3 18 d Kleafs : follow *a* +1 to  $\gamma$ any 6 +1 to 6 E 4 to 6 2 11 1711 1-2 4 n D to m X Parat

Da Page MARCHE .12 14:16 6 8 5 exo 1  $(\dagger)$ min (11)  $\mathcal{O}^{(l)}$ 1 (í 16 A (8 (12 8 6 5 12 (tv) Max hear (v)16 (16 12 Л following max hear Ì4 5 68 (8) Propenties 14 5, 8 ) 12 16 6 . PXS 4 G 8 2 7 13 5 6. 7 9 2 8 (1) (111) (1)(9 6 9 6 6  $\rightarrow$ Ŧ Т 8 (1)Ó 0 ١ leaf= [m]+1 ton =(5 + 09) $(\mathbf{V})$ i 8 7 > following Max hearp & roperchies S 3 C

atlantis Date Your Personal Exams G Eveny loaf. is a Max heap. Max-heapily algonithm) Ax-HEAPIEY (A, 9). 5 21  $\gamma = 2i + 1$ : if (I < A heap cize and A[I]>A[i]) langest = l else langest=1 (l & A-heap lize and A[m) > [angest]) if langest. if (langest = i) exchange A[1] with A[langest] MAR-HEAPIEY (A, largest) Z 0 13 exo .... So 10 langest F heap size = 10 D (14 0 ıl Cangest > F

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Date Page 10 9 I-) Rangut e=18 Total time complexity, (2×10gn) = [0(10gn) Space complexity 9 Ø no. of level (10gm) Z (Build may hear algorithm) BUILD - MAX- HEAP (A) A. beap inte = Alength fore (i= [A. Length/2] downto 1): MAX-ELEAPLEY (A,i) lex: 6, 5, 0, 8, 2, 13,3 9 1 to m/2 ] ) - non leaf +1 to 27) - leaf n-> 8

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atlantis Date Page Your Personal Exam Ć (note, hight) 0:63) 0(2) 2) 0(1) 51) (8,0) 6 A Maximum not of note present in level & ht (n>0) (8) = 0+ (F) total home O(h)  $=\frac{\ell \eta}{2}$ 42 ίa Σ n=0 0 (n) In order build a +ime complexity spall complexity = O (logn)

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· Extract - max from mAX HEAP: HEAP-EXTRACT-MAX (A) if (A. heap-site <1) ennorc" heap underflow? Constant time  $m_{0X} = A[1]$ ATI) = ATA- heap-cize] A. heap life = A heap life -1 MAX-HEAPIFY (A,1) } O(10gm) sime return max; (ex)o 100,50,20, 1, 3, 10, 5, Pelite - max value (troot value) Call Max heaf by 50 10 - Total time computity = O (logn) space complexity = 0 (10gm). • HEAP - Increase Key (Max-heap) o 17 Index Number HEAP-increase-Key (A, i, Key) if (Key < A[i]) enhor. A[i] = Key while (i) land  $A[\frac{1}{2}] < A[\frac{1}{2}]$ change  $A[\frac{1}{2}]$  and  $A[\frac{1}{2}]$ ;  $A[\frac{1}{2}] = \frac{1}{2}$ ; Z

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atlantis Date Page **Your Personal Exams** ex]: Increase element of tim balex 5 by (Kery) ۱ 100 ) = 530 20 Key = 300 6 10 15 (100 300) 100 20 W 100 (MAX) hearp A (300 15 10 10) Accusate ATT Complexity=O(10gm me prent Key Into max-beap 31 > To menta element in max hears Time complexity is = O (log n) Invent -100 200 20 30 10 5 1 15 jod 200 6 30 100 21 Û 10 IS) 200) 4 9 1 18 1.50

Pageour Personal (heap-operation) Key Increase Kuz Deletemon ment find max decreas 0(10gm) n (10gm) Mrx near O(1)OCitogn Ollogn Search delete Find min my trendom element trendem element  $\frac{O(m+n)}{=O(m)}$ O(m)O(n)HEAP SORT and analysis. HeapSort (A) BUILD-MAX-EHEAP(A) for (1= A. length down to 2) exchange A(1) = with A(9) A. heap size = A. heapsize - 1; Mox - HEAPIFY (A,1) 3 100 20 30 10 15 7 16 160 (00) (Max heap) 30 Max heapif) 20 (10) (100) 100 U 7 (10) 10 (15 20 heapify (子 max (IS (16) (20) (10) 100 (30 30 000 (10) 100

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Date 1000 16 7 10 (100 (30) 100 39 20 (2) 10 7 heapily (5) าฮ์ 15 0 (200) 16 20 30) 30 100 コ 20 16 30 15 100 10 annay Souted computity (Heap sont (n)Time for hight of the help. Learning hight of the Т 10gm)-+(m)for heapi 12 ( heep and heap sont) Sustins Question-1 heap with n'elements Inn element at the root, the Ith smallest Smallest in time found Can be UES (1) 0(1)  $\theta(logn)$ (a) O (mlogn)  $\theta(m)$ (1) 1st alement min - O(logn) Find 7th=o(1) detete 27, 2 Inunt = 6 × 0(legn) 34 ŋ <u>1</u> 1 Sth Time = 6(togr 6 × O(10gr) O (iogn) mir = O(10pm) + 6 + O(1 upm)+O(1) Scanned by CamScanner

Dat Page Buertiont binany max heap containing of numbers Ina be found in time mallest deme (b) O(logn) ( O(log lagn) () 0-(1). A(m) 5 3 1 100 3 - smalles TCŚ (2 O(logn) + O(1) 7/2 +1 to leaf = = (4 67 mini (mallest no.= D(m) Time taken to find Buestion - 3) this 15,20, 30,12,25,16 32, Mox beap what is resulting heap 100K1 32 32 16 30 G) tresulting order (32,30,25, 15, 12, 20, 16

atlantis Dat **Your Personal Exams** Suestion-9 3-any Max hear, D1,3,5,6,8,9 £ 9,6,3,1,8,5 1 3 9,3,6,8,5,1 (<del>1</del>)9,5,6,8,3,1 hich of the given requere foilow 3-any Max neera property 3-ary Max heap-3 2 8 6 6) (3)Ø Calibarys parent is greater than 8 children) 6 then mert (7,2,10,4) into so the result Insent-7 munt-2 (8) (6 6 8 (3 3 munt-10 Insent-4 TO 10 P 8 9 300 (S 6 10,7,9,8,3,1,5,2,6,4

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Date \_\_\_\_\_ Buestion - 5 Consider the process of Preenting an element Poto a max heap. If we perforce a binary search on the parpath from new heat to read to find the position of newly insented element, the number comparisons performed are heap-hight (sgn) When nelement # Binany seanch = logn <u>olody</u> 0 (10g logn) - applying Binary search on some problem which are have Time complexity of O(n) is I going to reduce the complexity to O(logn) Buestern - (6) we have a binary hear on n' elements with to meet n' more elements (not necesarily one after another ) into this heap. The total time required for this is I cary (BUILD hearp) O(2n) = O(n)- put all in element into annay and then Carl build heap. for m'element BT-c =o(m) 2n 1) Timerc = O(2n) = O(n).

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Gencedy Algoreithm Date WWW.gatenotes.m · Entiroduction of Gireedy algorithm ophimization : given a problem If I try to minimize or maximite there property then it is cary ophinitation problem. ophimitation Problems to 1 minimire Cost. max profit. maximite reliability. 5 minimize TURK Juni Generaly prethod and dynamic programming two programing petradener whith which a be used to solve optimization problem White Which -> Using careedy method we will not be able to Solve all the optimization problem. Diman Pynamic program can solve any ophmizeting of problem. (we want to apply promic programing can do consomiling better them compare to search) -> Time complexity of dynamic programming could be - O(m) or O(2m) Dynamic O(nK)V > beneficial O(27) Anot benetitienat Gineedy O(mu Liodes &

atlantis (Indfingle shoeter) D 6.34400 **Your Personal Exams** a Carles And Sack Cargerithe Knap sack, problem: means bag 10-MEZ M- capacity of bag) Objut-1 M=20 06-2 0h-3 (n-no.of object) profit 25 24 15 M=3 weight 18 15 10 15W-24P 2W= 24×2 15 when Caroly about profit -Weight Profit }2unit 0b-21: 18 25  $(24)^{(2)}_{(15)}$ 0b-\$2 2 18 20 28. 20 units When Crineedy about Weight -S 10 units W 15 0b-3: 10 10 (24)×10 06-2: a10 20 3 When Greedy about rake of proset & weight pofit percunits,  $ob-1: \frac{25}{18} = 1.4$ 0b-2:24 = 1.6  $0b-3 : \frac{15}{10} = 1.5$ 35 unit. raho of pent Profil-24 15 15 when Greedy about A 06-2: more Profit-A 06-3; (15)(言) 5 (31.5 20

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Date Page ee (Aropholity = 5 Algorithm = Servedy Knapsack <u>compute</u> <u>pilon</u>; <u>orning</u> <u>cupo</u> <u>toue</u> <u>southing</u> <u>cupo</u> <u>toue</u> <u>southing</u> <u>pilon</u>; <u>orning</u>) <u>to</u> <u>southing</u> <u>pilon</u>; <u>orning</u>) <u>to</u> <u>forc</u> <u>e</u>: sont objects in non increasing Order of Pho-for (i=1 ton friem souted with if (m>0 && w; 5 M) 0 (m)  $M = M - W_{ij}$  $P = P + P^{\circ};$ 2150 break;  $\frac{p_{m}(m)}{p_{m}} = p + \frac{p_{m}(M)}{p_{m}};$ TERT: 1 what is max profix get out of it <u> カニチョ と</u> M=15. 1.1 1 = 5 7 2 S Objuts 7 1 profits 1.5 6 . Alie .3 13 18 3  $\bigcirc$ 1 5 4 7 2 6 4 .5 3 3 5  $(\mathcal{I})$ 3724 16 5 (11)M=15 14 12 8 3 (2) 0. fnae < 2 Hon 7 3 P= 6+10+18+15+3+5(=) 6 =(55.2 5 M=15 unik.



# CLICK ON THE LINK GIVEN BELOW

