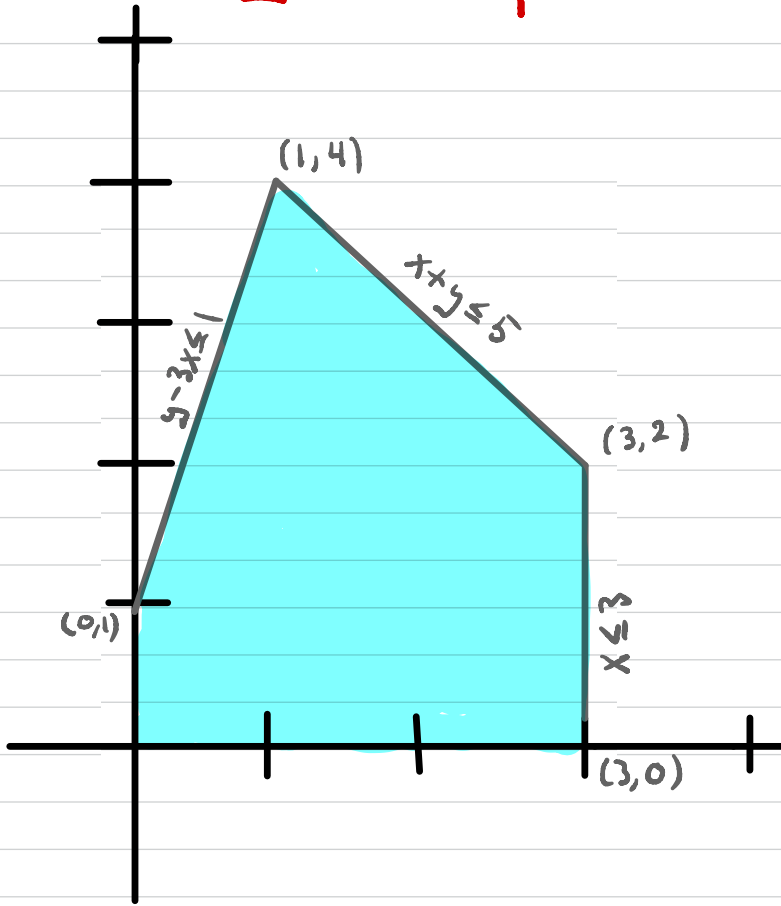


Linear

Programming

LP Recap



$$\begin{array}{l} \text{LP: } \max \quad x + 2y \\ \text{subject to} \quad \left. \begin{array}{l} x \leq 3 \\ x + y \leq 5 \\ -3x + y \leq -1 \\ x \geq 0 \\ y \geq 0 \end{array} \right\} \begin{array}{l} n \text{ vars} \\ m \\ \text{constraints} \end{array} \end{array}$$

Fact: For all LPs, there is an optimal solution at a **vertex**

Def: A vertex is a point x in the polytope ($x \in$ **feasible set**) which lies at the intersection of n hyperplanes in n dimensions.

Fact: If $n = \# \text{ vars}$, $m = \# \text{ constraints}$,
 $\# \text{ of vertices} \leq \underline{\hspace{2cm}}$

Linear Programming Alg 1: "Try all vertices"

Given m constraints $C = \{ \sum a_{ij} x_j \leq b_j \}$

For each subset $S \subseteq C$ of size n :

1. Solve for the point of intersection x^*

2. Check if x^* is feasible (satisfies all constraints)

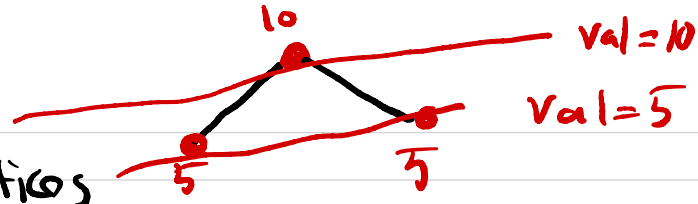
3. If so, compute value of x^*

Output **best** vertex found.

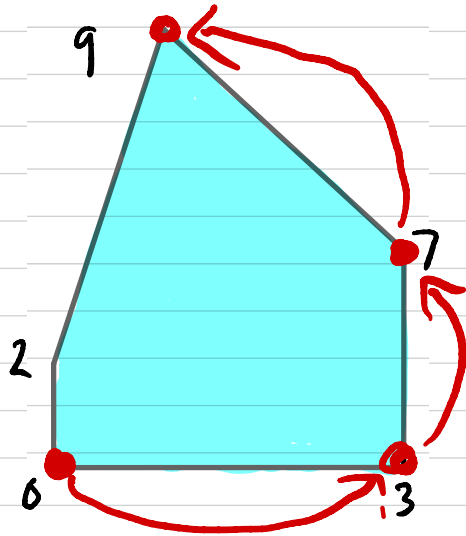
Time complexity $\approx \binom{m}{n} \approx$ exponentially large in n

LP alg 2: Simplex

1. Start at a vertex x^*
2. Look at all "neighboring" vertices
3. Find the neighbor y^* with best value
4. If y^* has a better val than x^* , move to y^* . Repeat.



$n=2$:



$n=3$: Constraints $\{A, B, C, D, E\}$

Vertex: (ABC)

Neighbors: $ABD, ABE, ACD, ACE, BCD, BCE$

Fact: Suppose n vars, m constraints
of neighbors \leq

Sad fact: Simplex still **exponential time**
(in the worst case)

Thm: Linear programs can be solved
in polynomial time.

[Khachiyan 1979]: Ellipsoid algorithm

[Kar markar 1984]: Interior points
algorithms

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Con Ed Takeover Action Fails in Westchester — Simon Wins in Bronx

By FRANK LYNN
Democratic voters in Westchester County passed a \$1.5-billion transportation bond issue yesterday in the New York State Legislature, while Westchester County voters rejected the same issue in their local election. In the Bronx, voters passed a \$1.5-billion transportation bond issue, while in Westchester County voters rejected the same issue.

Simon Getting Big Vote
With 60 percent of the vote, Mr. Simon was getting a big vote in the Bronx. In Westchester County, voters rejected the same issue. In the Bronx, voters passed the same issue.

F.A.A. Seeks Fine of \$1.5 Million For 'Unairworthy' Braniff Flights

By RICHARD WITKIN
The Federal Aviation Administration is seeking to impose a record \$1.5 million fine on Braniff Airways for conducting hazardous flights. The agency said that the violation, an illegal flight over the Grand Canyon, was a "gross violation" of Federal Aviation Regulations.

Interior Dept. Assaulted On Missing a Deadline For Species Protection

By PHILIP HANCOCK
House Democrats have assailed the Interior Department for missing a deadline Congress set for protecting endangered species. The House passed a resolution that would require the Interior Department to report on the progress of its efforts to protect endangered species.

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By MALLON W. BROWNE
A Soviet mathematician has discovered a new method for solving a long-standing problem in mathematics. The discovery is considered a major breakthrough in the field of mathematics.

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By FRANK LYNN
President Jimmy Carter is expected to ask for a loyalty check of his aides on politics. The President is believed to be planning to ask his aides to sign a statement of their political beliefs.

Philly's Governor
The Philadelphia City Council has elected a new mayor. The new mayor is expected to take office in January.

Mr. Carter's Visit
President Carter is expected to visit several cities in the next few weeks. His itinerary includes New York, Philadelphia, and Washington, D.C.

IRAN'S CIVIL GOVERNMENT OUT; HOSTAGES FACE DEATH THREAT; OIL EXPORTS BELIEVED HALTED

STUDENTS WARN U.S. ATOLATOH INSTRUCTS SECRET REVOLUTIONARY COUNCIL TO Form a Cabinet



At Tehran, a demonstrator held up a picture with the faces of President Carter and the Shah of Iran superimposed on a map of the Strait of Hormuz.

Main Iran Oil Port Reported Closed And Prices of Spot Petroleum Soar

By ANTHONY J. FARIH
Iran is reported yesterday to have closed its main oil port, the Strait of Hormuz. This action has caused a sharp rise in the price of oil on the world market. The closure is believed to be a result of the ongoing conflict between Iran and the United States.

Energy Dept. Accuses 9 Refiners Of \$1.18 Billion Oil Overcharges

By RICHARD L. LYONS
The Energy Department has accused nine oil refiners of overcharging the government by \$1.18 billion. The department claims that the refiners used illegal methods to increase their profits.

INSIDE

\$2.500 Scotch Gift
A high-ranking official of the State Department has received a \$2,500 gift of Scotch whisky. The gift is believed to be a bribe from a foreign source.

Yahweh, Many, and the Bible

By JOHN KIRKER
A new book by a religious scholar discusses the origins of the Bible. The author argues that the Bible is a collection of stories and myths that have been passed down through generations.

Yahweh, Many, and the Bible
The author of the book discusses the various interpretations of the Bible and the role of Yahweh in the Old Testament. He argues that the Bible is a complex work that has been shaped by many different cultures and religions.

Country's Membership Is Secret

By JOHN KIRKER
The membership of a secret organization is believed to be in the hands of a few individuals. The organization is thought to be involved in various activities, including espionage and sabotage.

INSIDE

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According to the American journal Science

Continued on Page A20, Column 3

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State Grants \$4.5 Million for Nuclear Energy

New York State announced today it was granting \$4.5 million for nuclear energy research. The grant will be used to fund research in the field of nuclear energy. The grant will be used to fund research in the field of nuclear energy.

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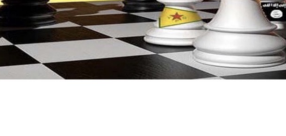
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President Carter after announcing that Robert S. Strauss, right, would buy his company. At left are Henry of Texas and other members of his cabinet.



Anna Khachian, a Soviet mathematician who discovered the method.



Anna Khachian at a dinner party in Moscow.



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I've leaned in and I can't get up

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SOVIETS HELP TO DELIVER U.S. ARMED SUPPLIES into Afghanistan. Helicopter from the United States is loaded with a Soviet helicopter to help relieve emergency. Page A13.

Cocaine Traffickers Kill 17 in Peru Raid On Antirug Team

LIMA, Peru, Nov. 18 — A band of cocaine traffickers here today a single raid on a Peruvian antirug team, killing at least 17 and capturing 100 more. The raid was the second in a series of attacks on the antirug team, which was sent to Peru to investigate the cocaine trade.

Peru prosecutors said half of the world's coca, the source of marijuana, is grown in the Peruvian Andes. Cocaine traffickers have been active in the region, and the raid was a major blow to the antirug team.

High Cuban Defector Speaks Out, Denouncing Castro as 'Impulsive'

By LESLIE MATLAND WEBSTER A Cuban defector who positions, according to United States authorities, that he was once a high-level Communist Party official, has spoken out against the Cuban government, denouncing Castro as 'impulsive' and 'incompetent'.

Mr. Lario said that he had been involved in a number of meetings with Mr. Castro in Havana in 1961, and that he had been involved in a number of meetings with Mr. Castro in Havana in 1961, and that he had been involved in a number of meetings with Mr. Castro in Havana in 1961.

AMERICANS IN POLL VIEW GOVERNMENT MORE CONFIDENTLY

But Postelection Inquiry Also Finds Most Think Reagan Will Ask Rise in Taxes

By ADAM CULVER The American public, on a level of confidence, has more confidence in the government than it has in the past, according to a new survey by the Gallup Organization.

Albany Leaders Predicting a Cut In Income Taxes

By JOHN BARRELL The Democratic majority in the Albany conference committee on a bill to amend the State Tax Law has predicted that a cut in personal income taxes is likely to be made in the next session.

Breakthrough in Problem Solving

By JAMES GLEICK A 21-year-old mathematician at A.T. Bell Laboratories has made a breakthrough in the study of complex systems, showing that a simple set of rules can lead to complex behavior.

Homeless Spend Nights in City Welfare Office

By SARAH RIMMER For the last 10 weeks, homeless families, mostly mothers and young children, have been spending their nights in plastic chairs, on newspapers or on the floor in New York City's emergency welfare office.

INSIDE The With 6 Aboard Missing

A signal with a aboard and a large number of people were missing on the ship, according to a report from the Coast Guard. The ship was carrying 6 people and was missing for several days.

TREASURY MAY ASK INCREASES IN TAXES OF SOME CONCERNS

OTHERS COULD PAY LESS Unprecise Setup Would be Challenged — Little Support in Congress Expected

By DAVID E. ROSENBLUM WASHINGTON, Nov. 18 — The Treasury will ask for tax increases to raise the rates of some taxpayers by modifying income tax rates and reduce the rates on other taxpayers by lowering corporate tax rates.

Albany Leaders Predicting a Cut In Income Taxes

By JOHN BARRELL The Democratic majority in the Albany conference committee on a bill to amend the State Tax Law has predicted that a cut in personal income taxes is likely to be made in the next session.

Homeless Spend Nights in City Welfare Office

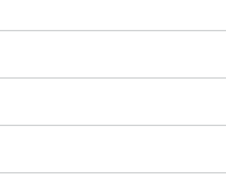
By SARAH RIMMER For the last 10 weeks, homeless families, mostly mothers and young children, have been spending their nights in plastic chairs, on newspapers or on the floor in New York City's emergency welfare office.

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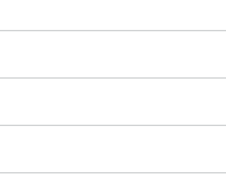
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NOVETS HELP DELIVER U.S. FARMER SUPPLIES IN Somalia. Helicopters from the United States are loaded onto a Soviet helicopter to help deliver emergency aid.

Cocaine Traffickers Kill 17 in Peru Raid On Antirug Team

LIMA, Peru, Nov. 18—A band of cocaine traffickers used a jungle of mountains to ambush and kill 17 Peruvian soldiers in a surprise raid on an antirug team...

Peru's defense forces have been unable to capture the cocaine traffickers who are believed to be operating in the jungle...

High Cuban Defector Speaks Out, Denouncing Castro as 'Impulsive'

By LESLIE MATLAND WEBSTER. A Cuban defector who speaks in Cuba's largest newspaper...

Mr. Llanusa said that he first moved to Miami in 1961, and then to New York in 1962. He said he had been in the United States for 22 years...

AMERICANS IN POLL VIEW GOVERNMENT MORE CONFIDENTLY

But Postelection Inquiry Also Finds Most Think Reagan Will Ask Rise in Taxes

By ADAM CLYMER. The American public, in a new survey, views the government more favorably than it did in a similar survey last year...

"Major Realignment?" The survey also found that 60 percent of the public and 60 percent of those who identify with the Democrats...

Among voters his support was highest among those who are 18 to 29 years old, those who are white, those who are married...

Breakthrough in Problem Solving

By JAMES GLEICK. A 28-year-old mathematician at A.T. & T. Bell Laboratories has made a startling theoretical breakthrough in the solving of systems of equations...

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OTHERS COULD PAY LESS. Unpreparation Setup Would be Changed—Little Support in Congress Explored



Senator Bob Dole

Albany Leaders Predicting a Cut In Income Taxes

By JOHN BARANELL. The Democratic and Democratic-Aid party politicians predicted that a personal income tax cut would be passed in Albany...

At the same time, the Albany Democratic Party, showing a strong lead in the polls, is expected to win the November election...

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These problems are fiendishly complicated systems, often with thousands of variables. They arise in a variety of commercial and government applications, ranging from allocating time on a communications satellite to routing millions of telephone calls over long distances...

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The discovery, which is to be formally published next month, is already circulating rapidly through the mathematical world. It has also set off a deluge of inquiries from brokerage houses, oil companies and airlines, industries with millions of dollars at stake in problems known as linear programming.

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Because problems in linear programming can have billions or more possible answers, even high-speed computers cannot check every one. So computers must use a special procedure, an algorithm, to examine as few answers as possible before finding the best one—typically the one that minimizes cost or maximizes efficiency.

A procedure devised in 1947, the simplex method, is now used for such problems of great progress, and this may well be one of them."

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Homeless Spent

By SARA RIMER

For the last 10 weeks, homeless families, mostly mothers and young children, have been spending weekend nights on plastic chairs, on countertops or on the floor in New York City's emergency welfare office because the city's welfare agency has run out of beds.

Other families have been waiting almost through the night while city welfare workers try to find temporary space for them in any of the 51 hotels scattered throughout Manhattan, the Bronx, Brooklyn and Queens that accept homeless families.

In some cases, the families leave the Manhattan office at 4 or even 5 A.M. for an hour's trip on the subway to hotels in the other boroughs that will require them to check out as early as 11 A.M. that same morning.

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