THE UCI LIBRARIES FALL 2019 EXHIBIT

FINDING THE EDGE

The Work and Insights of Edward O. Thorp ♥♣♦♠

THE UCI LIBRARIES • IRVINE, CALIFORNIA • 2019

Welcome to the UCI Libraries' 2019 Fall Exhibit!

Finding the Edge: The work and insights of Edward O. Thorp highlights the extraordinarily diverse life and career of Edward O. Thorp. As a UCI founding professor of mathematics, best-selling author, hedge fund manager and blackjack player, this exhibit features Thorp's mathematical odyssey from academia, to the casinos of Las Vegas, and the trading desks of Wall Street.

We are honored to have Thorp as our distinguished speaker at the opening night event on Monday, November 4, 2019. The exhibit includes select writings and memorabilia showcasing his personal and professional papers throughout his impressive career. Thorp was a founding member of the UCI mathematics department and became a professor who mathematically proved card-counting gives every player an edge. Thorp also funded an endowment to attract a pre-eminent professor in mathematics. To beat roulette, he and Claude Shannon invented the first wearable computer. Along with innovative applications of probability theory, Thorp is also *The New York Times* bestselling author of "Beat the Dealer," the first book to mathematically prove that the house advantage in blackjack could be overcome by card-counting. He also pioneered the use of quantitative investment techniques in the financial markets and has been called the "Godfather of Quants."

In 2013, Thorp received the UCI Alumni Association's highest honor, the Lauds & Laurels Extraordinarius. award, which recognizes outstanding individuals for their service to community, professional excellence and campus involvement.

This exhibit provides an inspirational view of Edward O. Thorp's boundless curiosity and intellectual drive towards "finding the edge" in science and business. The exhibit will be on display through March 2020 during regular library hours. I invite you to explore the exhibit, and to view additional thought-provoking exhibits at the UCI Libraries in the future.

Lorelei Tanji
University Librarian

A NATURAL TALENT

"I do not know what I may appear to the world; but to myself I seem to have been only like a boy playing on the seashore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."

Sir Isaac Newton quoted by Edward O. Thorp. *Higher Mathematics for Fun and Profit*. UCI community lecture on January 15, 1975. UCI Special Collections and Archives. Edward O. Thorp Papers.

Edward O. Thorp was born in Chicago in 1932. His father was an army officer who began teaching him mathematics at the age of three. As a precocious child, Thorp had contests with the local shopkeeper adding up customer bills in his head against the owner's result from an adding machine. He started the 1st grade early at the age 5.

In 1942, Thorp's family moved to Lomita, California (near Long Beach) where he enrolled in 6th grade at Orange Street Elementary School. Still advanced, at age 10 he entered 7th grade at Narbonne High School in fall 1943. His strongest memories of this time included getting up at 3 a.m. every morning to deliver the *LA Examiner* (starting at age 11) and using the money to buy chemicals, electronic equipment, and telescopes. He graduated after 6 years at Narbonne High School in 1949 at age 16.

1. **Thorp in High School.** 1947.

   Articles from the UCI Libraries Special Collections and Archives, Edward O. Thorp Papers.

   Narbonne High School offered very little in the way of academics. Edward O. Thorp was interested in science, but no one else shared this interest so he began teaching himself, starting a Chess Club and a Science Club at school. He said, "Physics, astronomy, mathematics, chemistry, a little biology—just by reading books and studying on my own–this also proved to be a benefit because I learned to think things through for myself. If something came up…and everybody would say no you couldn't, I wouldn't accept that. I would say, 'Well, I'll check it out for myself and see what I think.'" Unpublished biographical sketch. UCI Libraries Special Collections and Archives, Edward O. Thorp Papers.

2. **Eighth Science Talent Search.**

   Science Clubs of America for the Westinghouse Science Scholarships. 1949. Articles from the UCI Libraries Special Collections and Archives, Edward O. Thorp Papers.

   Edward O. Thorp said, "My neighbor Mr. Hodge (and fellow ham radio operator) had gotten a subscription to Science News-Letter for me…I saw a story that they had a Science Talent Search contest, and that turned out to be quite a revelation for me. Along with more than sixteen thousand high school students from all over the United States, I entered the Eighth Annual Search." Maya Ajmera. Conversations with Maya: A Discussion with Dr. Edward Thorp, Author of Beat the Dealer. *Society for Science & The Public*. October 27, 2017.

3. **Some Original Calculations.**

   Edward O. Thorp, 1949. Articles from the UCI Libraries Special Collections and Archives, Edward O. Thorp Papers.

   For his required contest essay, Edward O. Thorp wrote about, "Some fun things he had figured out for himself." He shared his calculations for finding the approximate positions of the planets in the sky by assuming their orbits were circular and his calculations for finding the index of refraction of a glass prism. Edward O. Thorp. *A Man for All Markets: From Las Vegas to Wall Street, How I Beat the Dealer and the Market*. Random House Publishing Group, 2017. Page 43.

4. **Local Student Wins Science Talent Search.**

   Long Beach Press Telegram. February 6, 1949.

   Articles from the UCI Libraries Special Collections and Archives, Edward O. Thorp Papers.

5. **Western Union Telegram.** February 2, 1949.

   Articles from the UCI Libraries Special Collections and Archives, Edward O. Thorp Papers.

   Edward O. Thorp said, "Winning the Science Talent Search was one of the main things that really opened my eyes to the world of science and what it was like. It was the first time I ever took a train. The year was 1949, and it was a three-day train ride to Washington, D.C." For the public evening exhibition, his display projects were a two-meter radio station he built, his solid fuel rockets testing results, and his testing of refraction in prisms. Maya Ajmera. Conversations with Maya: A Discussion with Dr. Edward Thorp, Author of Beat the Dealer. *Society for Science & The Public*. October 27, 2017.

6. **Invitation to STS Banquet.** March 7, 1949.

   Articles from the UCI Libraries Special Collections and Archives, Edward O. Thorp Papers.

7. **Photographs of Edward O. Thorp in Washington, D.C. 1949.**

   Articles from the UCI Libraries Special Collections and Archives, Edward O. Thorp Papers.

8. **President Harry Truman with the Science Talent Search Winners (1949).**

   Maya Ajmera. Conversations with Maya: A Discussion with Dr. Edward Thorp, Author of Beat the Dealer. *Society for Science & The Public*. October 27, 2017.

   Edward O. Thorp said, "we had an audience in the Oval Office with President Harry Truman. We all had our picture taken with him, and he shook each of our hands. I remember his hand very vividly still: It felt like a nicely upholstered, well-used leather armchair with a little talcum powder on it."

9. **Biographies of Science Talent Search Winners.**

   Science Clubs of America, 1949. Articles from the UCI Libraries Special Collections and Archives, Edward O. Thorp Papers.

10. **Narbonne Students Win Academic Awards.**

    Maya Ajmera. Conversations with Maya: A Discussion with Dr. Edward Thorp, Author of Beat the Dealer. *Society for Science & The Public*. October 27, 2017.

    Edward O. Thorp entered and won cash or college scholarship prizes from the Bank of America, the Southern California branch of the American Chemical Society, and the Southern California Physics Contest in addition to the Westinghouse Science Talent Search. "Because I was one of forty finalists in the 8th National Science Talent Search (out of 16,000 entrants), it made it easier to get scholarships at whatever university I wanted to go to. I could only afford to go to the University of California because the tuition was minimal at the time, $70 a year." Maya Ajmera. Conversations with Maya: A Discussion with Dr. Edward Thorp, Author of Beat the Dealer. *Society for Science & The Public*. October 27, 2017.

11. **Congratulatory Letter from the President of Bank of America, Torrance Branch, May 17, 1949.**

    Articles from the UCI Libraries Special Collections and Archives, Edward O. Thorp Papers.

12. **Bank of America Certificate of Achievement in Field of Laboratory Sciences (Chemistry).** 1949.

    Articles from the UCI Libraries Special Collections and Archives, Edward O. Thorp Papers.

Edward O. Thorp started college at the University of California, Berkeley in 1949. He then transferred to the University of California, Los Angeles (UCLA) in 1950 and received a Bachelor's Degree in Physics in 1953. He continued at UCLA as a PhD student in Physics where he ranked first (out of 44 students) on his qualifying exams. After achieving his Master of Arts Degree in Physics in 1955 and partially completed his PhD thesis on Mayer-Jensen nuclear shell theory, he encountered mathematics problems that caused him to take more math courses to work on quantum mechanical problems.

He switched his major and took additional mathematics courses to achieve his PhD in Mathematics in 1958. His thesis work was in the area of Functional Analysis, "Compact-Linear Operators in Normed Space."

In 1958, he and his wife Vivian moved to the East Coast so he could begin a position as the C.L.E. Moore Instructor at Massachusetts Institute of Technology (MIT), which he held until 1961. On the drive out east, they stopped in Las Vegas.

A WINNING HAND

13. **"The Optimum Strategy in Blackjack."**

    Roger R. Baldwin. *Journal of the American Statistical Association*. Vol. 51. No. 275. September 1956.

    Edward O. Thorp read this article before a seminal trip to Las Vegas in 1958. He condensed the main features of the strategy onto a card that fit into the palm of his hand and played blackjack for the first time. This experience got him hooked on the game. Thorp wrote, "The atmosphere of ignorance and superstition surrounding the blackjack table that day had convinced me that even good players didn't understand the mathematics underlying the game. I returned home intending to find a way to win." Edward O. Thorp. *A Man for All Markets: From Las Vegas to Wall Street, How I Beat the Dealer and the Market*. Random House Publishing Group, 2017. Page 62.

"For me blackjack was a game of math, not luck."

Edward O. Thorp. *A Man for All Markets: From Las Vegas to Wall Street, How I Beat the Dealer and the Market*. Random House Publishing Group, 2017. Page 93.

14. **"A Favorable Strategy for Twenty-One."**

    Edward O. Thorp. *Proceedings of the National Academy of Sciences*. Vol. 47. No 1. January 1961.

    Edward O. Thorp published his discovery in the *Proceedings of the National Academy of Sciences*. This journal required a member of the academy to approve and forward the author's work, which led to Thorp's introduction to the mathematician, Claude Shannon, who was also at Massachusetts Institute of Technology (MIT). Thorp and Shannon would later collaborate and create a wearable computer to beat the game of roulette.

    Thorp also presented his findings at the American Mathematical Society in Washington D.C. in January 1961. His talk, "Fortune's Formula: The Game of Blackjack" created quite a stir.

15. **Collage of Edward O. Thorp's formulas to figure out blackjack odds and strategy.** 1962.

    Articles from the UCI Libraries Special Collections and Archives, Edward O. Thorp Papers.

    As Edward O. Thorp began to delve into the theory of probability, he realized he could beat the game of blackjack and he could prove it. "I started with the fact that the strategy I had used in the casino assumed that every card had the same chance of being dealt as any other during play… But I realized that the odds as the game progressed actually depended on which cards were still left in the deck and that the edge would shift as play continued, sometimes favoring the casino and sometimes the player." Edward O. Thorp. *A Man for All Markets: From Las Vegas to Wall Street, How I Beat the Dealer and the Market*. Random House Publishing Group, 2017. Page 67.

    In 1959, while Thorp was working at the Massachusetts Institute of Technology (MIT), he began working on his blackjack theory using an IBM 704 computer to run through 34 million different combinations in which the cards could be dealt. He concluded that given a bet limit of $500, the game could be consistently beaten at the rate of $125 an hour.

16. **Edward O. Thorp playing blackjack at the Tropicana Hotel, November 19, 1963.**

    Courtesy of Edward O. Thorp. Photo by Don Cravens. *Life Magazine*.

17. **Letter and "UNIVAC" cards from The Showboat Casino in Las Vegas, January 10, 1962.**

    Articles from the UCI Libraries Special Collections and Archives, Edward O. Thorp Papers.

    "When starting my calculations... I sent an inquiry to twenty-six Nevada casinos. My object was to learn how the rules varied from one establishment to another, in particular to see if some places had rules even more favorable than usual. Thirteen of the twenty-six casinos were kind enough to reply to an ignorant academic." Edward O. Thorp. *A Man for All Markets: From Las Vegas to Wall Street, How I Beat the Dealer and the Market*. Random House Publishing Group, 2017. Page 81.

"What intrigued me was the possibility that merely by sitting in a room and thinking, I could figure out how to win."

Edward O. Thorp. *A Man for All Markets: From Las Vegas to Wall Street, How I Beat the Dealer and the Market*. Random House Publishing Group, 2017. Page 66.

18. ***Beat the Dealer: A Winning Strategy for the Game of Twenty One.***

Edward O. Thorp. Random House, 1962.

This book mathematically proved that the casino advantage in blackjack could be overcome by card counting. Beat the Dealer would go on to sell over one million copies and profoundly change the casino industry. Edward O. Thorp's strategy exposed the innate vulnerability of the game and made blackjack a test of ability, not luck.

19. **Prototype of the Beat the Dealer device + Picture of Edward O. Thorp holding device.**

Courtesy of Edward O. Thorp.

This hand-held gadget is a prototype. It can count multiple cards and provide "touch" read out capabilities.

20. **Outcome of conference presentation.**

1. "Can Beat Black-Jack, says Prof." Richard H. Stewart. *Boston Globe*. January 24, 1961.
2. "You Can So Beat the Gambling House At Blackjack, Math Expert Insists." Thomas Wolfe. *Washington Post*, January 25, 1961.
3. "Can a 'Formula' Beat Blackjack? Ralph Chapman. *New York Herald Tribune*. January 29, 1961.

"The national AP wire service ran Tom Wolfe's story, causing thousands of letters and phone calls to pour into the MIT Math Department...Before I gave my talk at the meeting, I hadn't envisioned the clamor and publicity that would follow. Instead, I'd expected scholars to look at my work, be very surprised at the results, and eventually agree that it was correct. But rather than this happening in a quiet, slow-paced academic way, I was besieged by strangers all wanting a piece of me." Edward O. Thorp. *A Man for All Markets: From Las Vegas to Wall Street, How I Beat the Dealer and the Market*. Random House Publishing Group, 2017. Pages 82-83.

21. **Simple Explanation of the Game of Blackjack.**

Blackjack is the American variant of a globally popular banking game known as Twenty-One. The objective of the game is to beat the dealer in one of the following ways:

i. Get 21 points on the player's first two cards (called a blackjack);

ii. Reach a final score higher than the dealer without exceeding 21; or

iii. Let the dealer draw additional cards until their hand exceeds 21

22. **Publicity After Book Published.**

1. Edward O. Thorp. A Prof Beats the Gamblers. *Atlantic Monthly*. June 1962. Page 41-46.
2. Author unknown. Games: Beating the Dealer. *Time Magazine*. January 25, 1963. Page 70.
3. Paul O'Neil. The Professor Who Breaks the Bank. *Life Magazine*. March 27, 1964. Page 81.
4. David E. Scherman. It's Bye! Bye! Blackjack. *Sports Illustrated*. January 13, 1964. Page 19.

"I launched an army with Beat the Dealer. Thus continued the great blackjack war between casinos and the players that still rages, more than fifty years after the invention of card counting."

Edward O. Thorp. *A Man for All Markets: From Las Vegas to Wall Street, How I Beat the Dealer and the Market*. Random House Publishing Group, 2017. Page 11.

23. **Simple 5 Count Strategy for One Deck**

What to Count:

Start with the count of 0.

For each 5 observed add +1.

For each ACE observed subtract -1.

Explanation: If the count is greater than or equal to 2, double your bet. If the count is less than 1, make the minimum bet.

Question: Given this scenario, would you bet more or less on your next hand?

"All strategies apply to multiple decks and various numbers of remaining cards simply by dividing the cards by the player's guess as to the equivalent number of decks of cards not yet played. Example: six deck game looks like about four decks worth of cards (208) left. Divide count by 4 to get "true" or corrected count." - Edward O. Thorp.

BEAT THE HOUSE

"Dr. Thorp may be qualified at mathematics but he is sophomoric in gambling."

Author unknown. Nevada Gaming Chief Disputes Professor's 'All-Win' System. *Denver Post*. March 30, 1964.

"How the heck do I know how he does it? I guess he's got one of them mathematical minds or photographic memories, or something." This was Cecil Simmons, the casino boss at the Desert Inn, talking on the phone with Carl Cohen, the Sands casino manager. It was the mid-1960s and they were discussing a book that would have a most profound impact on Las Vegas casinos and their approach to the game known as 21 or blackjack. "All I know," Simmons roared, "is he wrote a book that teaches everyone how to win every time they play blackjack. I'm just telling you, this book-learning SOB has ruined us . . . we're out of the blackjack business."

Author unknown. Counting on Blackjack. *Las Vegas Style*. May 5, 1993.

24. **Response to Beat the Dealer: A Winning Strategy for the Game of 21 from the casinos.**

    1. Jude Wanniski. Gamblers Shuffle Blackjack Rules Back to Old Deal. *National Observer*. June 15, 1964.
    2. Colin McKinlay. BlackJack Rule Change. *Las Vegas Review Journal*. April 2, 1964.
    3. Author unknown. Nevada Gaming Chief Disputes Professor's 'All-Win' System. *Denver Post*. March 30, 1964.
    4. Author unknown. Vegas Casinos Cry Uncle, Change Rules. *LA Times*. April 2, 1964.
    5. Author Unknown. Vegas Casinos Change Game to Cope with Aggie Professor. *Sante Fe: The New Mexican*. April 3, 1964.
    6. Cy Ryan. System Upsets the System. Unknown publication and date.

    On April 1, 1964, the Nevada Resort Hotel Association announced they were changing the rules of blackjack. Splitting pairs and doubling down would be restricted and the deck of cards would be reshuffled after just a couple of deals. This significantly increased the house advantage. As Edward O. Thorp predicted, these rule changes were incredibly unpopular with both card counters and non-card counters. People stopped playing blackjack and the casinos had no choice but to reinstate the original rules.

"...I forged a system for beating the game. Then I was ridiculed by the casino beast . . . I found myself barred, cheated, ... and generally persona non grata at the tables. It felt good to know that, just by sitting in a room and using pure math, I could change the world around me."

Edward O. Thorp. *A Man for All Markets: From Las Vegas to Wall Street, How I Beat the Dealer and the Market*. Random House Publishing Group, 2017. Page 111.

25. **Six-deck Shoe and Discard Tray.**

Traditionally red or black resembling a woman's high heel shoe, a "dealing shoe" is commonly used in casino's to hold multiple decks of playing cards. Until the early 1960s, single-deck blackjack was the standard in Nevada, 4 and 6-deck shoes, casinos' theorized, would thwart card counters as multiple decks made it harder to keep accurate track of the deck.

Edward O. Thorp's response, "[4, 6, 8-deck shoes] were supposed to make card counting more difficult. But for those who used the High-Low System, it wasn't much harder." Edward O. Thorp. *A Man for All Markets: From Las Vegas to Wall Street, How I Beat the Dealer and the Market*. Random House Publishing Group, 2017. Page 113.

"The green felt table was a stage and I was an actor on the stage. A card counter who wanted to be allowed to continue playing had to put on an effective act and present a non-threatening persona."

Edward O. Thorp. *A Man for All Markets: From Las Vegas to Wall Street, How I Beat the Dealer and the Market*. Random House Publishing Group, 2017. Page 108.

26. **Letter written by Edward O. Thorp. April 6, 1963.**

"I was successfully disguised and not recognized."

27. **Disguise Paraphernalia.**

As Edward O. Thorp begins to win too often and is recognized as the author of the book, *Beat the Dealer*, he is repeatedly asked to leave casinos. Casinos are considered to be private clubs and can exclude whomever they please.

To get around being barred from casinos, Thorp experimented with disguises, including contact lenses, sunglasses, a beard, and drastic changes of wardrobe and table behavior.

In *A Man for All Markets: From Las Vegas to Wall Street, How I Beat the Dealer and the Market* (2017), Thorp recalls an encounter with one disguise, "When I introduced myself… they saw a bearded fellow wearing a brightly patterned Hawaiian shirt, wraparound sunglasses, and jeans… [Later on] I decided to put my disguise to the acid test...I shaved off the beard, replaced the prescription sunglasses with contact lenses, and combed my hair differently. A sports jacket and tie completed the transformation. I had no problem playing in the establishments that had barred my bearded self just the day before" (pages 107-108).

28. **Cheating by the Casinos.**

1. Address Book used to take notes about cheating. Date Unknown.
2. Letter to Thorp describing different casinos cheating. July 27, 1963.
3. Note. Date Unknown. Describes Bonanza Casino cheating.
4. Author Unknown. Dice Cheating Closes Vegas Casino. Newspaper Unknown. Date Unknown.

Collection of letters and notes to and from Edward. O Thorp and newspaper article discussing cheating by casinos. From the UCI Libraries Special Collections and Archives, Edward. O Thorp Papers.

Common cheating practice, "Peek at the next card to be dealt, the so-called top card. Then if that card was good for the player, deal the card just below it instead, the second card, in the likelihood it was worse. On the other hand, if the dealer was giving a card to himself, he would take the top card if it was good for him, and otherwise deal himself the second. The dealer who does this is a heavy favorite to beat the player… It is also nearly impossible to prove it ever happened. Cheating was so relentless during those days in Las Vegas that I spent as much time learning about the many ways it was being done as I did playing. Everywhere we went, we reached a point where we were cheated, barred from play, or the dealer reshuffled the cards after every hand." Edward O. Thorp. *A Man for All Markets: From Las Vegas to Wall Street, How I Beat the Dealer and the Market*. Random House Publishing Group, 2017. Pages 102-103.

29. **Marked Cards + Yellow Glasses.**

One way dealers would cheat is they would wear yellow tinted glasses, through which they could see identifying marks on the back of the cards. If the card on top was a good card for the player, the dealer dealt him the next card, or "second" instead.

This pack of cards has identifying marks on the back that you do not need glasses to detect. Can you see them?

30. **Dunes Hotel Directory.**

31. **Drugged coffee mug at Dunes Hotel while playing Baccarat in 1963.**

After figuring out blackjack, Edward O. Thorp turned his attention to other casino games. Baccarat has similarities to blackjack and therefore was the next logical game to tackle. During a trip to Las Vegas in 1963, Thorp did very well playing baccarat. On the third night, it seems that the casino decided to put a stop to this.

"The pit boss and his minions seemed pleased to see me. Then they volunteered 'coffee with cream and sugar, just the way you like it.' I was deep into the first shoe happily winning and drinking my coffee when suddenly I couldn't think. I could no longer keep count...The wives saw that my pupils were hugely dilated. A nurse said that she had seen this often when people who had used drugs were admitted to her hospital..." Edward O. Thorp. *A Man for All Markets: From Las Vegas to Wall Street, How I Beat the Dealer and the Market*. Random House Publishing Group, 2017. Page 142.

Despite that incident, Thorp was satisfied that his theories about side bets and how to take advantage when there are fewer cards in the shoe were correct. Thorp said, "We had proven the system worked at the tables like it did in theory. As a result, both the Dunes and the Sands removed the natural 8 and natural 9 bets." Edward O. Thorp. *A Man for All Markets: From Las Vegas to Wall Street, How I Beat the Dealer and the Market*. Random House Publishing Group, 2017. Page 144.

32. **Postcard Collection of Las Vegas from the 1960s.**

33. **10 Count Strategy for One Deck**

What to Count:

Start with the count of 0.

Add +4 for the following cards: Ace, 2, 3, 4, 5, 6, 7, 8, 9.

Subtract -9 for the following cards: 10, Jack, Queen, King.

Explanation: Start with the minimum bet. As the count gets higher, increase your bet. When the count starts to return to 0 or go negative, you should lower your bet to the minimum.

Question: Given this scenario, would you bet more or less on your next hand?

A SPIN OF THE WHEEL

An Explanation of Roulette.

Derived from the French for "little wheel," Roulette has players choose single numbers, groups of numbers, or colors to place bets on. Once bets have been placed, a croupier (dealer) spins the wheel in one direction, and spins a ball in the opposite direction on the track running on the outer edge of the wheel. Eventually the ball loses momentum, falling onto the wheel of one of the 38 colored and numbered pockets.

Edward O. Thorp and Shannon felt they could predict where the ball would end up because casinos allowed players to bet for a few seconds while the ball was spinning. This gave them the necessary time to track the ball's momentum.

34. **"The Lives They Lived: Claude Shannon, B. 1916; Bit Player."**

James Gleick. *New York Times Magazine*. Dec. 30, 2001.

Claude Shannon (1916-2001) was an American mathematician, electrical engineer, computer scientist, and cryptographer known as "the father of information theory." Shannon's theories laid the groundwork for the electronic communications network now used all over the planet. Shannon and Edward O. Thorp met in September 1960 at Massachusetts Institute of Technology (MIT) and applied mathematics to see if they could predict where the ball would land on a roulette wheel. Together they would spend about eight months building the first wearable computer.

Thorp originally became intrigued about the roulette wheel while in high school studying planetary positions. He felt there was an analogy between the circling roulette ball and an orbiting planet, or of a pendulum that is gradually dissipating energy. "Since planetary positions were accurately predictable, I thought I might be able to forecast the outcome of a roulette pin." Edward O. Thorp. *A Man for All Markets: From Las Vegas to Wall Street, How I Beat the Dealer and the Market*. Random House Publishing Group, 2017. Page 44.

35. **Letter from Claude Shannon to Edward O. Thorp about the wearable computer.**

August 6, 1961. Articles from the UCI Libraries Special Collections and Archives, Edward O. Thorp Papers.

36. **Wearable Computer.**

Courtesy of The Massachusetts Institute of Technology Museum.

"The computer has 12 transistors that allowed its wearer to time the revolutions of the ball on a roulette wheel and determine where it would end up. Wires led down from the computer to switches in the toes of each shoe, which let the wearer covertly start timing

the ball as it passed a reference mark. Another set of wires led up to an earpiece that provided audible output in the form of musical cues -- eight different tones represented octants on the roulette wheel. When everything was in sync, the last tone heard indicated where the person at the table should place their bet." Billy Steele. Engadget.com. *The Unlikely Father of the Wearable Computing. Distro.* September 13, 2013.

Using the model, they were able to predict any single number with a standard deviation of 10 pockets. This converts to a 44% edge on a bet on a single number. Betting on a specific octant gave them a 43% advantage. Thorp and Shannon went to Las Vegas in August 1961 to test the computer in a real environment. It was successful "turning small piles of dime chips into large ones." The difficulty they encountered had to do with output. While the small computer worn around the waist was inconspicuous enough, the earpiece proved more difficult.

"Even though they were steel, they were so fine that they broke frequently, leading to long interruptions while we returned to our rooms and went through the tedious process of doing the repairs and then rewiring [the bettor]." Between this and the knowledge that casinos could change the rules at any time to stop allowing betting after the ball was spun, they ended their project. Edward O. Thorp. *A Man for All Markets: From Las Vegas to Wall Street, How I Beat the Dealer and the Market*. Random House Publishing Group, 2017. Page 133.

37. **Electrical diagram for wearable computer/Schematic of Roulette wheel.**

Circa 1961. Articles from the UCI Libraries Special Collections and Archives, Edward O. Thorp Papers.

"Well into one winning session, a lady next to me looked over in horror. Knowing I should leave, but not why, I raced to the restroom and there in the mirror saw the speaker peeking out from my ear canal like an alien insect."

Edward O. Thorp. *A Man for All Markets: From Las Vegas to Wall Street, How I Beat the Dealer and the Market*. Random House Publishing Group, 2017. Page 133.

38. **Man's shoe.**

Using the roulette computer was a two-person job. One person would wear the device and time the wheel. Edward O. Thorp and Claude Shannon had trained their big toes to operate switches hidden in their shoes. The other person, the bettor, would sit at the table with a receiver (a tiny loudspeaker pushed into one ear canal and connected by very thin wires to the radio receiver, which was concealed under his clothing), hearing the results as various audio tones.

39. **"The Invention of the First Wearable Computer. Edward O. Thorp. "**

Proceedings of the Second International Symposium on Wearable Computers. Pittsburgh Pennsylvania. October 19-20, 1998.

40. **Wearable Computers Outlawed in Nevada on May 30, 1985.**

Articles from the UCI Libraries Special Collections and Archives, Edward O. Thorp Papers.

1. Senate Bill Number 467. 1985 State Senate (Nevada, 1985).
2. Blackjack Devices to Count Cards Barred by Nevada Assembly. *Los Angeles Times*. May 24, 1985.

In 1961 there were no laws in Nevada about the use of computers in casinos. Twenty-four years later Nevada passed an emergency measure banning use or possession of any device to predict outcomes, analyze probabilities, help with strategy, or count cards.

41. **Postcard from The Mint Casino in Las Vegas.** 1965.

Picturing a Roulette Gaming Guide.

42. **MIT Timeline.**

"A Brief History of Wearable Computing." Bradley Rhodes. wearables.www.media.mit.edu/projects/wearables/timeline.html.

1966. Edward O. Thorp and Claude Shannon reveal their invention of the first wearable computer, used to predict roulette wheel [MIT]. The system was a cigarette-pack sized analog computer with 4 push buttons. A data-taker would use the buttons to indicate the speed of the roulette wheel, and the computer would then send tones via radio to a bettor's hearing aid. Though the system was invented in 1961, it was first mentioned in Edward O. Thorp's, *Beat the Dealer*, revised ed. 1966. The details of the system were later published in *Review of the International Statistics Institute*, V.37:3, 1969. Thorp also disclosed a similar system for beating the Wheel of Fortune gambling game in *Life Magazine*, March 27, 1964, Pages 80-91.

A BRIEF HISTORY OF WEARABLE COMPUTING.

Foundations (F): Thinkers, innovations, and experiments that helped pave the way for wearable computers.

Complete Systems (C): Complete wearable computers (general or special purpose)

1268 (F): Earliest recorded mention of eyeglasses

1665 (F): Robert Hooke calls for augmented senses

1762 (F): John Harrison invents the pocket watch

1907 (F): Aviator Alberto Santos-Dumont commissions the creation of the first wristwatch

1945 (F): Vannevar Bush proposes the idea of a "Memex" in his article "As We May Think" [MIT]

1960 (F): Heilig patents a head-mounted stereophonic television display

1960 (F): Manfred Clynes coins the word "Cyborg"

1966 (C): Ed Thorp and Claude Shannon reveal their invention of the first wearable computer, used to predict roulette wheels [MIT]

1966 (F): Sutherland creates first computer-based head-mounted display [MIT]

1967 (F): Bell Helicopter experiments with HMDs with input from servo-controlled cameras [Bell Helicopter]

1967 (C): Hubert Upton invents analogue wearable computer with eyeglass-mounted display to aid lipreading [Bell Helicopter]

1968 (F): Douglas Engelbart demonstrates chording keyboard in NLS (oN Line System) [SRI]

1972 (C): Alan Lewis invents a digital camera-case computer to predict roulette wheels [Cal Tech]

1977 (C): CC Collins develops wearable camera-to-tactile vest for the blind [Smith-Kettlewell]

1977 (C): HP releases the HP 01 algebraic calculator watch [Hewlett-Packard]

1978 (C): Eudaemonic Enterprises invents a digital wearable computer in a shoe to predict roulette wheels [Eudaemonic Enterprises]

1979 (F): Sony introduces the Walkman [Sony]

1980 (F): Upton and Goodman file for patent on LED raster display [Textron, Inc]

1981 (C): Steve Mann designs backpack-mounted computer to control photographic equipment

1983 (C): Taft commercializes toe-operated computers based on Z-80's for counting cards

1984 (F): William Gibson writes Neuromancer

1986 (C): Steve Roberts builds Winnebiko II, a recumbent bicycle with on-board computer and chording keyboard

1987 (F): The movie Terminator is released

1989 (F): Private Eye head-mounted display sold by Reflection Technology [Reflection Tech]

1990 (C): Gerald Maguire and John Ioannidis demonstrate the Student Electronic Notebook, with Private Eye and mobile IP [Columbia]

1990 (F): Olivetti develops an active badge system, using infrared signals to communicate a person's location [Olivetti]

1991 (C): Doug Platt debuts his 286-based "Hip-PC" [Select Tech]

1991 (C): CMU team develops VuMan 1 for viewing and browsing blueprint data [CMU]

1991 (F): Mark Weiser proposes idea of Ubiquitous Computing in Scientific American [Xerox PARC]

1993 (C): Thad Starner starts constantly wearing his computer, based on Doug Platt's design [MIT]

1993 (C): BBN finishes the Pathfinder system, a wearable computer with GPS and radiation detection system [BBN]

1993 (F): Thad Starner writes first version of the Remembrance Agent augmented memory software [MIT]

1993 (F): Feiner, MacIntyre, and Seligmann develop the KARMA augmented reality system [Columbia]

1994 (C): Lamming and Flynn develop "Forget-Me-Not" system, a continuous personal recording system [Xerox EuroPARC]

1994 (C): Edgar Matias debuts a "wrist computer" with half-QWERTY keyboard

1994 (F): DARPA starts Smart Modules Program

1994 (F): Steve Mann starts transmitting images from a head-mounted camera to the Web [MIT]

1996 (F): DARPA sponsors "Wearables in 2005" workshop

1996 (F): Boeing hosts wearables conference in Seatle

1997 (F): Creapôle Ecole de Création and Alex Pentland produce Smart Clothes Fashion Show

1997 (F): CMU, MIT, and Georgia Tech co-host the first IEEE International Symposium on Wearables Computers

43. The Mathematics of Gambling.

Edward O. Thorp. *The Mathematics of Gambling*. Gambling Times; First Paperback Edition. 1984.

"More than twenty years after the publication of *Beat the Dealer*, the best-selling book on winning at blackjack, Dr. Edward O. Thorp again focused his attention on gambling games with an analysis of Baccarat, Backgammon, Blackjack, Roulette, and Wheel of Fortune. In easy-to-understand language, learn what a leading mathematician discovered in thirty years of computer-assisted research. This is the long-awaited publication to Dr. Thorp's accumulated work on gambling." Back cover of the *Mathematics of Gambling*.

44. HIGH/LOW STRATEGY FOR ONE DECK

What to Count:

Start with the count of 0.

Add +1 for the following cards: 2, 3, 4, 5, 6.

Cards 7, 8, and 9 = 0.

Subtract -1 for 10, Jack, Queen, King, Ace.

Explanation: When the count is high, the remaining deck is favorable to the player and you should bet more. When the count is low, the casino (house) benefits and you should bet low.

Question: Given this scenario, would you bet more or less on your next hand?

HIGHER MATHEMATICS AT UCI

45. **UCI Hires Top Mathematician: He 'Beat the Dealer' at Las Vegas.**

    Charles H. Loos. *Daily Pilot*. June 4, 1965. Page 2. Articles from the UCI Libraries Special Collections and Archives, Edward O. Thorp Papers.

46. **Edward O. Thorp at the Blackboard. 1967.**

    Edward O. Thorp was hired in 1965 as an Associate Professor by the University of California, Irvine as part of the newly formed Mathematics Department. He remained with the Mathematics Department until 1976. A colleague of his characterized Thorp's work with the department, "In an era when society is demanding in the return for support, mathematics demonstrate its usefulness, Thorp is by far the most visible and active applied mathematician on our faculty." Unpublished letter, UCI Special Collections and Archives. Edward O. Thorp Papers.

47. **Mathematics Faculty at UCI. 1967.**

    Edward O. Thorp taught courses in probability and functional analysis. He also worked with and researched mathematical economics, game theory and applications, and statistical metric spaces. He said when he first arrived, "I'm very impressed with UCI and I'm particularly impressed with the mathematics department being organized by Dr. Gelbaum. I think UCI will become one of the great universities in the country."

48. **Elementary Probability.**

    Edward O. Thorp. New York: Wiley, 1966.

    Edward O. Thorp wrote a textbook based on the syllabus he developed teaching classes at UCI. Thorp said in an interview, "Most people don't have an intuition for statistics and chance. They think if red comes up ten times in a row... the odds are better that it will be black the next time. And that's not true. Chance phenomena are a hard concept to most people. You have to train your mind to understand them." In this example (Page 34) he shows how a roulette wheel can be used to examine and create a "finite probability space that can be realized in practice." Draft speech, UCI Special Collections and Archives. Edward O. Thorp Papers.

49. **"Optimal Gambling Systems for Favorable Games."**

Edward O. Thorp. *Revue de l'Institut International de Statistique/Review of the International Statistical Institute*, Vol. 37, No. 3., 1969. Pages 273-293.

Professor Thorp revisited his experiments with probability and gaming into a single overall synthesis. A reviewer at the time said of it, "It has the virtue of its originality and is distinguished by its application to completely realistic situations (vs conventional idealizations). Connects modern developments in probability theory with the information sciences, in particular by showing how computers can be used, not only to investigate experimental situations but as a guide to obtaining results in pure and quite abstract mathematics as well."

50. **"Higher Mathematics for Fun and Profit." Lecture 1975.**

February 25, 1975. Articles from the UCI Libraries Special Collections and Archives, Edward O. Thorp Papers.

51. **"Physical Science Lectures Scheduled."**

UCItems January 6-12, 1975. Articles from the UCI Libraries Special Collections and Archives, Edward O. Thorp Papers.

52. **Photographs of Edward O. Thorp.**

1975. Courtesy of Edward O. Thorp.

Problems in finance and developing mathematical models of stock trading were another strong interest. He enjoyed sharing his knowledge with the public and his colleagues regarding how investments can be made using computer developed models. In 1977, Edward O. Thorp joined the School of Business as a Professor of Mathematics and Finance at UC Irvine (UCI). He remained at UCI in this position until he left UCI in 1982.

53. **Extensions of the Black-Scholes option model.**

Black–Scholes options pricing model is used to determine the fair price or theoretical value for a call or a put option based on six variables such as volatility, type of option, underlying stock price, time, strike price, and risk-free rate. The Black-Scholes pricing model is important because anyone can use it to assess the value of an option.

Edward O. Thorp worked on his own independent variation of this idea starting in 1968. "I speculated that in a risk neutral world I can set both opposing options (gain or loss) equal to a riskless rate corresponding to the time until expiration (which, as it happens, gives the future Black-Scholes formula). I didn't see how to prove the formula but I decided to go ahead and use it to invest, because there was in 1967-68 an abundance of vastly overpriced (in the sense of *Beat the Market*) OTC options. Amazingly, I ended up breaking

even overall, on about $100,000 worth of about 20 different options sold short at various times from late '67 through '68. The formula has proven itself in action. It was an intuitive derivation that was kept secret for the benefit of my investors and myself." Thorp's notes. Libraries Special Collections and Archives, Edward O. Thorp Papers.

The formula, developed by three economists – Fischer Black, Myron Scholes and Robert Merton – is perhaps the world's most well-known options pricing model. It was introduced in their 1973 paper, "The Pricing of Options and Corporate Liabilities," published in the *Journal of Political Economy*. Black passed away two years before Scholes and Merton received the 1997 Nobel Prize in Economics for their work in finding a new method to determine the value of derivatives.

54. **Institute of Mathematical Statistics letter from George J. Resnikoff.**

    August 19, 1974. Articles from the UCI Libraries Special Collections and Archives, Edward O. Thorp Papers.

55. **Letter to Edward O. Thorp from Fischer Black.**

    March 21, 1973. Articles from the UCI Libraries Special Collections and Archives, Edward O. Thorp Papers.

A CAREER IN QUANTITATIVE FINANCE

1964 Began self-education on financial markets, investing, and economics.

"I never even thought about finance until I was 32."

Tren Griffin. A Dozen Lessons on Investing from Ed Thorp [Blog Post]. 25iq My Views on the Market, Tech, and Everything Else, July, 2017.

56. ***THE SPECULATIVE MERITS OF COMMON STOCK WARRANTS AND HANDWRITTEN NOTE.***

    Sidney Fried. R. H. M. Associates. 1954. UCI Libraries Special Collections and Archives, Edward O. Thorp Papers.

1965 Began teaching at UC Irvine as founding member of the Mathematics Department.

1966 Co-authored *Beat The Market: A Scientific Stock Market System* with Dr. Sheen Kassouf, a founding faculty member of the UC Irvine Department of Economics. This book in part motivated Fischer Black and Myron Scholes to prove an identical formula, the Black–Scholes model, which received the Nobel Prize in Economics.

57. ***BEAT THE MARKET: A SCIENTIFIC STOCK MARKET SYSTEM.*** Edward O. Thorp, Sheen Kassouf. Random House, 1967.

1967 Had a theoretical breakthrough to arrive at a neat formula for determining the "correct" price of a stock's warrant, i.e., a security issued by a company that gives the owner the right to buy stock at a specified price. Began to manage hedged portfolios for clients.

1968 Became acquainted with Warren Buffet through Ralph Waldo Gerard who became Dean of the Graduate Division at UC Irvine.

1969 Launched Convertible Hedge Associates, renamed in 1974 to Princeton Newport Partners, with stockbroker Jay Regan. A bicoastal operation, the Newport Beach office was the think tank and trade generator, and New York the business office and trading desk.

58. ***"PLAYING THE ODDS: COMPUTER FORMULAS ARE ONE MAN'S SECRET TO SUCCESS IN MARKET."***

    Jonathan R. Laing. *Wall Street Journal*. 1974, September 23. UCI Libraries Special Collections and Archives, Edward O. Thorp Papers.

1979 10th anniversary of Princeton Newport Partners, at which point it was up 409% for the decade. Its original $1.4 million capital base had grown to $28.6 million.

1982 Edward O. Thorp concluded working as a full professor at UCI to "…focus on competing with the wave of mathematicians, physicists, and financial economists who were now flocking to Wall Street from academia."

1983 Princeton Newport Partners pioneered new trades, including a huge one-time trade that took place as AT&T was divided into a new company. This trade, on December 1, 1983 was at the time the largest dollar amount for a single trade in the history of the New York Stock Exchange.

59. ***BRASS ENGRAVED DEAL TROPHY OF TRANSACTION.*** Courtesy of Edward O. Thorp.

1987 Launched a family office called Edward O. Thorp & Associates.

1988 Closed Princeton Newport Partners. Its original $1.4 million capital base had grown to $273 million, with investment positions totaling $1 billion.

60. **"BEAT THE DEALER."** William Baldwin. *Forbes*. May 5, 1986. UCI Libraries Special Collections and Archives, Edward O. Thorp Papers.

1991 Discovered Bernie Madoff's Ponzi scheme when a client asked Edward O. Thorp to review his portfolio, which included an investment with Bernard L. Madoff Investment Securities. Bernie Madoff was eventually arrested in 2008.

61. **BERNIE MADOFF LEAVING COURT AFTER A BAIL HEARING IN NEW YORK CITY, 2009.** Kathy Willens (photographer). Associated Press.

1994 Launched an investment partnership called Ridgeline Partners.

2002 Closed Ridgeline Partners. It gained 18% per year over its eight years of operation.

2003 Attended the Berkshire Hathaway Annual Shareholders Meeting. Edward O. Thorp originally began investing in Berkshire Hathaway Class A stock in 1982, when each share was valued at $982.50.

62. **SHAREHOLDER MEETING BADGE.** Courtesy of Edward O. Thorp.

2011 Edward O. Thorp co-edited *The Kelly Capital Growth Investment Criterion*, World Scientific Publishing Company, 2011, with Leonard C. MacLean and William T. Ziemba. The book is a compilation of academic papers on the Kelly Criterion Formula, which per Edward O. Thorp, **"tells you how to allocate money between risky alternatives and gives you an idea of how much to allocate to each."**

Leslie P. Norton and Dan Lam. *The Stockpicker's Burden, and Other Lessons*. Barron's. March 19, 2018.

63. ***KELLY CAPITAL GROWTH INVESTMENT CRITERION.*** Leonard C. MacLean, Edward O. Thorp, William T. Ziemba (Eds.) World Scientific Publishing Company. February 11, 2011.

2017 Edward O. Thorp authored *A Man for All Markets: From Las Vegas to Wall Street, How I Beat the Dealer and the Market*. Random House, 2017.

64. ***A MAN FOR ALL MARKETS: FROM LAS VEGAS TO WALL STREET, HOW I BEAT THE DEALER AND THE MARKET.*** Edward O. Thorp. Random House, 2017.

TIPS FROM THE MASTER

THREE TYPES OF INVESTORS

Content adapted from Edward O. Thorp's direct quotes from the following sources:

Leslie P. Norton and Dan Lam. The Stockpicker's Burden, and Other Lessons. *Barron's.* March 19, 2018.

Edward O. Thorp. *A Man for All Markets: From Las Vegas to Wall Street, How I Beat the Dealer and the Market*. Random House, 2017.

Tren Griffin. A Dozen Lessons on Investing from Ed Thorp [Blog Post]. 25iq My Views on the Market, Tech, and Everything Else, July, 2017.

Scott Patterson. Old Pros Size Up the Game; Thorp and Pimco's Gross Open Up on Dangers Of Over-Betting, How to Play the Bond Market. *Wall Street Journal, Eastern edition*; March, 2008.

PASSIVE INVESTORS

PEOPLE WHO WANT TO DO WELL AND NOT SPEND A LOT OF TIME.

- If you're a long-term investor, equities are the way to go. Invest in a broad, no-load, US stock index fund with a very low expense ratio, such as the Vanguard S&P 500 or the Vanguard Total US Stock Index.
- They do better than maybe 90% of all other investors who are busy paying fees to advisers.
- They will beat most of the others who will be dragged down by fees and costs and punished by what I call "the scared-rabbit syndrome," which is that they run out at the bottom and get back in at the top.

EXPERIMENTAL INVESTORS

PEOPLE WHO JUST ENJOY MESSING AROUND IN THE MARKET AND ARE WILLING TO SPEND TIME TO GET AN EDUCATION.

- I say, take a small amount of capital and learn. Put most of it in an index fund where it will grow while you are busy getting your education and paying for it.
- If they want to learn more, they should go out and have their go at trying to make some money, but they shouldn't use the bulk of their resources to do this.
- If they find something that really works then they can start putting more money into it. They'll find that most of the time they haven't really found anything that really works.

PROFESSIONAL INVESTORS

MOST PEOPLE WHO WANT TO BE PROFESSIONAL INVESTORS DON'T ACTUALLY GET AN EDGE.

- Those people get a start somehow in the market just like I got a start with an option's formula, so I have an edge.
- I build an organization, which is small, and it gradually grows. It gets more and more skills.
- You, basically, get over the hurdle and get yourself established. If you can do that as a professional then you're kind of on your way to collecting what people call Alpha, excess return.

MISTAKES MADE & LESSONS LEARNED

Adapted from: *Edward O. Thorp. A Man for All Markets: From Las Vegas to Wall Street, How I Beat the Dealer and the Market.* Random House Publishing Group, 2017. Chapter 11.

MISTAKE 1

I bought one hundred shares at $40 and watched the stock decline over the next two years to $20 a share, losing half of my investment. I had no idea when to sell.

LESSONS:

- Most stock-picking stories, advice, and recommendations are completely worthless.
- Avoid Anchoring: The error was in the way I thought about the problem of when to sell, choosing an irrelevant criterion - the price I paid - rather than focusing on economic fundamentals like whether cash or alternative investments would serve better. Behavioral finance theorists call this anchoring a subtle and pervasive aberration in investment thinking.

MISTAKE 2

Two "expert" longtime insurance investors claimed to have become rich investing in life insurance companies. According to their figures, the A. M. Best AAA index, which refers to the health of an insurance company, of the average price of such companies had gone up in each of the last twenty-four years, and they had plausible arguments that this would continue. Sure enough, the amazing winning streak they had identified ended just after my purchase, and we all lost money.

LESSON:

- Do not assume that what investors call momentum, a long streak of either rising or falling prices, will continue unless you can make a sound case that it will.

MISTAKE 3

In the early 1960s the demand for silver was exceeding supply, and I expected prices to spurt sharply. Believing the economic supply and demand analysis was correct, I opened a Swiss bank account to buy silver, with the encouragement of local promoters who got a commission for making the arrangements. I borrowed to buy 3x as much silver as I could have with cash alone. Silver rose as predicted and the promoters recommended using the profits together with more bank loans to buy yet more silver.

Then the price of silver dropped. As people sold silver to capture their profit, the price dropped rapidly, just enough to wipe me out for a few thousand dollars.

LESSONS:

- Though I was right in my economic analysis, I hadn't properly evaluated the risk of too much leverage, i.e. borrowing money.
- When the interests of the salesmen and promoters differ from those of the client, the client had better look out for himself.

PERSONAL FINANCE POINTERS

Content adapted from Edward O. Thorp's direct quotes from the following sources:

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Edward O. Thorp. Edward O. Thorp. *A Man for All Markets: From Las Vegas to Wall Street, How I Beat the Dealer and the Market*. Random House, 2017.

Tren Griffin. A Dozen Lessons on Investing from Ed Thorp [Blog Post] 25iq My Views on the Market, Tech, and Everything Else, July, 2017.

Scott Patterson. Old Pros Size Up the Game; Thorp and Pimco's Gross Open Up on Dangers Of Over-Betting, How to Play the Bond Market. *Wall Street Journal, Eastern edition*; March, 2008.

THINK OF THE TRADEOFFS AMONG HEALTH, WEALTH, AND TIME.

- You can trade time and health to accumulate more wealth.
- You can invest time and money on health.
- You can trade money for time by working less and buying goods and services that save time.

TO GET AN IDEA OF WHAT YOUR TIME IS WORTH, TAKE A MOMENT NOW TO THINK ABOUT HOW MUCH YOU WORK AND THE INCOME YOU GET FROM YOUR EFFORT.

- Once you know your hourly rate you can identify situations where buying back some of your time is a bargain and other situations where you want to be selling more of your time.

THE LESSON OF LEVERAGE, I.E. BORROWING MONEY, IS THIS:

- Assume that the worst imaginable outcome will occur and ask whether you can tolerate it. If the answer is no, then reduce your borrowing.

COMPARING GAMBLING TO INVESTING

Content adapted from Edward O. Thorp's direct quotes from the following sources:

Leslie P. Norton and Dan Lam. The Stockpicker's Burden, and Other Lessons. *Barron's*. March 19, 2018.

Edward O. Thorp. Edward O. Thorp. *A Man for All Markets: From Las Vegas to Wall Street, How I Beat the Dealer and the Market*. Random House, 2017.

Tren Griffin. A Dozen Lessons on Investing from Ed Thorp [Blog Post] 25iq My Views on the Market, Tech, and Everything Else, July, 2017.

Scott Patterson. Old Pros Size Up the Game; Thorp and Pimco's Gross Open Up on Dangers Of Over-Betting, How to Play the Bond Market. *Wall Street Journal, Eastern edition*; March, 2008.

CHANCE CAN BE THOUGHT OF AS THE CARDS YOU ARE DEALT IN LIFE. CHOICE IS HOW YOU PLAY THEM.

WHEN THERE IS MONEY AND NOT FULL ACCOUNTABILITY, WHETHER IT IS IN CASINOS OR ON WALL STREET, THERE'S GOING TO BE STEALING AND CHEATING.

- At blackjack, it can be marked cards, second-dealing, or a stacked deck.
- On Wall Street, it can be Ponzi schemes and other frauds, such as insider trading, fake news, or stock price manipulation.
- Mathematically, the biggest difference is that the odds can be figured exactly or approximately for most gambling games, whereas the numbers are usually far less certain in the securities markets.
- How are casinos similar to the stock market?

IMAGINE YOU ARE INVESTING IN AN INDEX FUND. THE CASINO IS MR. MARKET, WHO OFFERS YOU A COLLECTION OF BETS. IF YOU CHOOSE AN INDEX FUND, SAY VTSAX [THE VANGUARD TOTAL STOCK MARKET INDEX FUND], ON A TYPICAL DAY IT RANDOMLY FLUCTUATES BY 1%.

BUT THERE IS A LONG-TERM DRIFT IN YOUR FAVOR OF ABOUT ONE TWENTIETH OF A [PERCENTAGE POINT]. SO IF YOU HAD $1 MILLION IN YOUR PORTFOLIO IN SUCH AN INDEX, MR. MARKET WILL COME TO YOU EACH DAY AND SAY, LET'S FLIP A COIN. IF IT'S 50/50, THEN YOU'LL WIN $10,000 OR LOSE $10,000. BUT I'LL PAY YOU $500 IF YOU PLAY THAT DAY.

- If you play for one day, you'll be losing $9,500 or winning $10,500.
- If you play for a year, the chances are moderately good that you'll be ahead because those $500 payments add up and overcome the fluctuation. Maybe a third of the years, you'll be down and unhappy.
- If you play for 10 years or 20 years, then those $500 payments just keep adding up.

SO A SIMILAR PROCESS HAPPENS AT BLACKJACK TABLES. IF YOU'RE COUNTING CARDS, YOU HAVE A LITTLE DRIFT IN YOUR FAVOR. BUT IN BLACKJACK YOU PLAY 100 HANDS AN HOUR, AND IN A WEEK YOU MAY PLAY 4,000 HANDS. IN A CASINO, YOU GET TO THE LONG RUN FAIRLY QUICKLY.

- What can your blackjack strategy tell us about how to manage risk in today's markets?
- Don't over bet. Suppose you have a 5% edge over your opponent when tossing a coin. The optimal thing to do, if you want to get rich, is to bet 5% of your wealth on each toss - but never more. If you bet much more you can be ruined, even if you have a favorable situation.

NEWPORT LIFE & PHILANTHROPY

65. **"The Invisible Wife."**

    Tom Wolfe. *Harper's Magazine*. January 1, 1980. Page 57.

    The "*In Our Times Column*" featured this short story mentioning Edward O. Thorp and the public's fascination with his success in the financial world.

66. **Edward O. Thorp at the PNP Offices in Newport Beach.**

    Circa 1989. Courtesy of Edward O. Thorp.

67. **Edward O. Thorp at his Newport Office.** Circa 2004. Courtesy of Edward O. Thorp.

    Edward O. Thorp retired from UCI in 1982. He was able to spend more time with his family and to concentrate on running Princeton Newport Partners (PNP) and subsequently his own investment portfolio.

68. **UC Irvine: Sue and Bill Gross Stem Cell Research Center.**

    California Institute for Regenerative Medicine (CIRM) Annual report 2008. Page 16. Articles from the UCI Libraries Special Collections and Archives.

    Edward O. Thorp and his wife Vivian Thorp donated towards the establishment of the Stem Cell Research Center at UC Irvine. Thorp said about the donation, "Vivian and I believe that private donations like ours in support of stem cell research at UCI will have a benefit both to our community and to our country that is immeasurably greater than the amount of the gift. We expect donor support will allow continuing breakthroughs by UCI's stellar research team and this will be leveraged by attracting many times as much in continuing state support."

69. **UC Irvine Alumni Lauds and Laurels.**

    Program. May 31, 2018. Page 2.

    Articles from the UCI Libraries Special Collections and Archives.

    Edward O. Thorp was the 2013 recipient of the UC Irvine Alumni Association's highest Lauds & Laurels honor, the Extraordinarius award. Since 1971, the UCI Alumni Association and its board of directors has presented Lauds & Laurels, a tradition that has recognized and honored more than 750 outstanding alumni and members of the UCI community for their service to the community, professional excellence and campus involvement.

70. **Plaque celebrating the establishment of the Edward O. Thorp and Vivian Thorp Endowed Chair in Mathematics.**

January 20, 2004. Courtesy of Edward O. Thorp.

Edward O. Thorp and his wife Vivian Thorp generously donated funds in 2004 to UC Irvine to establish an endowed chair in the School of Physical Sciences. One unique stipulation was Edward O. Thorp would continue to manage the funds. He said, "The gift (will be)…. an exercise in finance because it will support the research of an individual mathematician of exceptional talent while using the power of compound growth to create one of the most richly endowed department chairs in the world."