Blockchain Basics and Beyond:

A Guide for Security-Minded Students

Source: https://www.gbtech.net/the-truth-about-blockchain/

Negein Immen

Table of Contents

Introduction

What is Blockchain?

At its core, blockchain is a system for recording transactions across a decentralized network of computers. Imagine a tamper-proof digital notebook shared by a group: when someone adds a new entry, everyone gets a copy, but it only counts once the group agrees it's valid. This consensus-before-recording is what makes blockchain unique.

Rather than storing data in one place, blockchain distributes it across a global network of nodes. When a transaction—like sending crypto or updating a smart contract—is added, every node verifies it. Once approved, it becomes part of an unchangeable record. Altering it later would require convincing the majority of the network, which is incredibly hard and expensive.

This decentralized design makes blockchain transparent, secure, and resilient. No single person or organization controls it, and history can't be quietly rewritten. That's why it underpins cryptocurrencies like Bitcoin, launched in 2009, and why it's now being used far beyond digital money—for supply chains, healthcare, legal automation, and even voting systems.

What is in this Guide?

This guide is for students in computer science and related fields who want a clearer, safer path into blockchain. When I first started learning, I found most resources either confusing, scattered, or paywalled—often requiring risky trial-and-error with digital wallets that can easily be targeted by hackers. This guide is meant to walk around those barriers.

We'll begin with the fundamentals: how blockchain works, how it's secured with hashing, and how consensus algorithms keep the system honest. From there, you'll explore real-world use cases and academic resources to see blockchain in action. By the end, you'll have the resources to write your first smart contract, giving you a strong foundation for your own projects.

Tips and Tricks for Using this Guide

- For the smoothest learning experience, try following this guide in the order that resources appear.
- If you're just looking to understand how blockchain works, the first section will give you everything you need.
- If you want to go a step further and build a standout project for your resume, make time for the second and third sections—they help you brainstorm real-world ideas and then guide you through creating a polished, deployable smart contract.
- Blockchain comes with a lot of new vocabulary and concepts. Don't worry if you need to loop back to earlier terms or explanations.

1. Core Concepts and Cryptographic Foundations

Blockchain can seem overwhelming at first, but it all begins with a few powerful ideas. This section breaks down the core concepts that make blockchain work—from decentralization and distributed ledgers to the cryptographic tools that secure it all. You'll explore how hashing, digital signatures, and consensus algorithms form the backbone of blockchain's security and reliability. These foundational topics will give you the context needed to understand not just how blockchain functions, but why it's trusted in so many high-stakes applications today.

i. *How Bitcoin Works Under the Hood*

Educational YouTube Video Introducing Bitcoin and Blockchain

Location

https://www.youtube.com/watch?v=bBC-nXj3Ng4

Description

How Bitcoin Works Under the Hood is an educational YouTube video by Grant Sanderson, creator of the YouTube channel 3Blue1Brown, which uses animated visuals to explain the concepts of blockchain. This 26-minute video offers a compelling introduction to the technical foundations of Bitcoin and blockchain by breaking down key topics such as hashing, Proof of Work (PoW), public-key cryptography, and decentralized consensus mechanisms. Sanderson's visuals guide viewers through each component of the blockchain process, making abstract ideas both accessible and intuitive.

Overall, the video provides an essential conceptual framework for understanding how blockchain secures digital transactions and why the system is resistant to tampering. It demystifies the inner workings of Bitcoin without requiring prior experience in cryptography or mathematics, making it an ideal starting point for beginners looking to build a strong technical foundation before delving into more advanced blockchain topics. It's also worth noting that while the video focuses on the Proof-of-Work (PoW) algorithm, many other consensus mechanisms—such as Proof of Stake and Proof of Authority—are also widely used in modern blockchain systems. These alternatives will be covered in a later resource.

Tips

- The video assumes no prior experience with blockchain but does move quickly—pause frequently and take notes to fully absorb the material.
- Watch 2:25 to 7:21 closely since this part explains ledgers and digital signatures, key concepts for understanding how blockchain ensures trust and security.

ii. *Blockchain 101 – A Visual Demo*

Interactive YouTube Video on Blocks and Hashes

Location

https://www.youtube.com/watch?v=_160oMzblY8

Description

Blockchain 101 – A Visual Demo is an educational YouTube video created by Anders Brownworth that introduces the core principles of blockchain technology through an interactive, browser-based demonstration. In this video, Brownworth breaks down complex concepts into manageable parts, guiding viewers through how individual blocks are created, how cryptographic hashes secure data, and how these blocks are linked together to form a tamper-evident chain. Through a hands-on interface, he demonstrates how even a small change to the data in one block alters its hash and subsequently invalidates all the blocks that follow—emphasizing the importance of immutability and integrity in blockchain systems. Brownworth also briefly introduces the idea of consensus mechanisms, explaining how distributed systems maintain agreement over a shared ledger without a central authority.

What sets this video apart is its simplicity and clarity. Rather than relying on abstract theory, Brownworth uses real-time visual feedback to show how blockchains function at a low level, making it easier for beginners to grasp the underlying logic. Moreover, this video lays the groundwork for deeper technical understanding while remaining approachable and intuitive.

Tips

- The interactive demo used in the video is publicly accessible at https://andersbrownworth.com/blockchain/blockchain, allowing users to follow along and experiment while watching.
- Watch 0:16 to 2:08 closely since this part explains hashing and how changing a single character in one block affects the entire chain—this is a crucial concept for understanding blockchain immutability.
- To reinforce understanding, pause the video after each demonstration and try recreating the steps in the browser tool yourself.

iii. "All Major Blockchain Consensus Algorithms Explained"

Web Article on Blockchain Consensus Algorithms

Location

https://medium.com/@learnwithwhiteboard_digest/all-major-blockchain-consensus-algorithms-explained-6934b4f5d47a

Description

"All Major Blockchain Consensus Algorithms Explained" is an educational article featured in Medium's *Learn with Whiteboard* series that breaks down the most widely used consensus mechanisms in blockchain technology. The article begins by establishing the central role of consensus algorithms in validating transactions and securing blockchain networks without centralized control. It then explains key mechanisms—including Proof of Work (PoW), Proof of Stake (PoS), Delegated Proof of Stake (DPoS), and more—highlighting how each one functions, the problems it aims to solve, and its unique trade-offs. Moreover, one of the article's strengths is its ability to translate abstract theory into real-world relevance. By referencing how these algorithms are implemented in leading blockchain networks such as Bitcoin and Ethereum, it demonstrates the practical implications of each approach—particularly in areas like energy consumption, scalability, decentralization, and security.

Overall, this resource provides not just a technical breakdown, but a nuanced understanding of how different consensus algorithms shape the behavior and values of the blockchains they support. It is especially valuable for learners preparing to evaluate or design blockchain solutions with specific performance, security, and governance goals in mind.

Tips

- It's suggested to focus on understanding PoW and PoS first, as they form the foundation of many major blockchain networks like Bitcoin and Ethereum.
- Pay attention to how each algorithm balances security, decentralization, and scalability—often referred to as the blockchain trilemma.
- Consider the context in which a consensus model is used. Some models are better suited for public blockchains, while others, like PoA, are more appropriate for private or enterprise networks.

2. Blockchain in Academia and its Evolving Impact

Now that you have a solid understanding of how blockchain works and the mechanisms that secure it, this section explores how the technology is being actively researched, developed, and applied within academic settings. You'll also gain insight into blockchain's broader impact on society—from finance and healthcare to governance and sustainability. This section is a great place to gather inspiration, discover innovative use cases, and start thinking about ideas for your own blockchain project.

i. *IEEE Xplore Digital Library*

Index on Academic Blockchain Developments

Location

https://ieeexplore.ieee.org/Xplore/home.jsp

Description

The IEEE Xplore Digital Library, maintained by the Institute of Electrical and Electronics Engineers (IEEE), is an online database indexing peer-reviewed journal articles, conference proceedings, technical standards, and other scholarly materials in electrical engineering, computer science, and related fields. With millions of full-text documents, IEEE Xplore is an essential resource for accessing cutting-edge research, particularly in emerging fields like blockchain technology.

The platform features in-depth research on topics such as consensus mechanisms, smart contract design, blockchain security models, scalability solutions, and performance evaluations of decentralized systems. It also hosts technical standards and proposals, offering insight into how blockchain is being applied in real-world systems—from finance and supply chain to IoT and energy grids. Whether you're looking for foundational theory or cutting-edge experimentation, IEEE Xplore supplies a rigorous and reliable starting point for in-depth exploration.

Tips

- Use advanced search filters (such as keywords + date range + publication type) to narrow down results to the most relevant and up-to-date papers.
- Access through your university's library portal to gain full-text access—many articles are behind a paywall unless you have institutional access.
- Pay attention to conference papers from events like IEEE Symposium on Security and Privacy or IEEE International Conference on Blockchain—these often include the latest research.
- If you're new to academic research, start by reading abstracts and conclusions to quickly assess a paper's relevance before diving into the full text.

ii. *Blockchain: Research and Applications*

Professional Journal on Blockchain Research and Applications

Location

https://www.sciencedirect.com/journal/blockchain-research-and-applications

Description

Blockchain: Research and Applications is a peer-reviewed academic journal published by Zhejiang University Press and hosted on the ScienceDirect platform. This journal focuses exclusively on the latest blockchain research and its practical applications across a wide range of industries, including finance, healthcare, supply chain management, cybersecurity, and government systems. The journal features a diverse range of content, including protocol design, consensus mechanisms, scalability solutions, decentralized application (dApp) architectures, and cross-disciplinary use cases.

Moreover, this journal is a valuable resource for staying current with real-world innovations and scholarly discussions surrounding blockchain technology. Its articles are grounded in rigorous research and often present data-driven case studies, theoretical models, and experimental results—making it ideal for both technical understanding and academic writing. Whether you're planning a blockchain project or studying blockchain adoption trends, this journal supplies a solid, research-based foundation.

Tips

- Use the journal's "Top cited" or "Latest published" tabs to find impactful and timely research topics.
- Accessing full articles may require institutional login—check if your university library provides access to ScienceDirect.
- Many articles include extensive bibliographies, which can help you discover additional resources for deeper research.
- Review article abstracts and keywords first to gauge relevance before reading the full text, especially when browsing multiple papers.
- Consider using this journal as a source for emerging trends and case studies that can support or inspire your own projects in blockchain development and security.

3. Smart Contracts and Building with Blockchain

Now that you understand how blockchain works, how it's being developed in academia, and where it's applied, you're ready to start building. One of the most impactful ways to contribute is by creating smart contracts—self-executing programs on platforms like Ethereum that power decentralized applications (dApps). The following resources will guide you through writing and deploying your own smart contract. These tools are beginner-friendly and perfect for turning your blockchain knowledge into a working project.

i. *How to Code Your First Ethereum Smart Contract*

Interactive YouTube Video on Deploying Smart Contracts

Location

https://www.youtube.com/watch?v=ooN6kZ9vqNQ

Description

How to Code Your First Ethereum Smart Contract is an interactive, beginner-focused video tutorial created by Dapp University, a popular YouTube channel dedicated to blockchain development. This tutorial serves as a practical introduction to Solidity, the primary programming language for writing smart contracts on the Ethereum blockchain. It walks viewers through the complete process of building, compiling, and deploying a simple smart contract using Remix, an online integrated development environment (IDE) tailored for Solidity development.

The tutorial explains core Solidity syntax, the structure and lifecycle of a smart contract, and how Ethereum's gas model, state changes, and immutability principles affect contract behavior. The tutorial also demonstrates how to interact with deployed contracts within Remix's interface, reinforcing both programming logic and blockchain mechanics. No prior experience with smart contract programming is required, making this an ideal hands-on entry point for those transitioning from theoretical understanding to practical dApp development.

Tips

- Follow along using the Remix IDE (https://remix.ethereum.org) so you can write and test the code in real time without installing anything locally.
- Pause and replay sections as needed—the video is paced for beginners but covers a lot of new concepts quickly.
- Be sure to test the contract on the Remix JavaScript VM before experimenting with testnets or real deployments.

ii. "Smart Contracts and Solidity"

Open-Source Technical Documentation on Smart Contracts

Location

https://github.com/ethereumbook/ethereumbook/blob/develop/07smart-contracts-solidity.asciidoc#intro_chapter

Description

Chapter 7, "Smart Contracts and Solidity", from the *Ethereum Book*, written by Andreas M. Antonopoulos and contributions from the Ethereum GitHub community, offers a thorough, open-source guide to the Ethereum platform, focusing on smart contract development. This chapter provides an in-depth exploration of Solidity, the primary language for Ethereum smart contracts, and guides readers through the essential steps of writing, compiling, testing, and deploying smart contracts.

The chapter covers the core principles of Solidity, including how to define functions, manage state variables, handle events, use constructors, apply inheritance, and manage visibility modifiers. It also explains how these concepts are implemented in the context of the Ethereum Virtual Machine (EVM), giving readers a clear understanding of how the Ethereum system executes smart contracts at a low level. Unlike video tutorials, this written guide functions more like a developer's manual, making it useful for both learning and long-term reference.

Tips

- Start with the introductory section to get a sense of the Solidity development workflow before jumping into syntax-heavy examples.
- Use this chapter alongside the Remix IDE (https://remix.ethereum.org/) to practice writing and deploying the contracts discussed.
- It's suggested to bookmark this chapter as a long-term reference guide—its clear explanations and structured layout make it an excellent tool to revisit as you gain more experience.