Bicycle Gear and Chain Drive Analysis

This document presents detailed calculations for a standard 21-speed bicycle with 3 front chainrings (22T, 32T, 42T) and 7 rear sprockets (14T, 16T, 18T, 20T, 22T, 24T, 28T). The wheel size is 700C (0.700 m diameter, 2.199 m circumference), and crank length is 170 mm.

Assumptions:  
- Pedal force range: 100–300 N  
- Crank length: 0.170 m  
- Wheel radius: 0.35 m  
- Wheel circumference: 2.199 m  
- Cadences considered: 60 and 90 RPM

# Standard Chain Drive Material

Most bicycle chains are made of medium carbon or alloy steels with surface treatments for durability.  
- Inner/Outer Plates: Medium carbon steel (AISI 1050–1080)  
- Rollers and Bushings: Case-hardened alloy steel  
- Pins: Hardened alloy steel  
  
Surface Treatments:  
- Nickel or zinc plating for corrosion resistance  
- PTFE (Teflon) coatings for friction reduction  
  
Mechanical Properties:  
- Tensile strength: 900–1200 MPa  
- Hardness: 40–55 HRC after heat treatment  
- Density: ~7.85 g/cm³

# Gear Calculations

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Front (T) | Rear (T) | Gear Ratio | Meters/Rev | Speed @60 RPM (km/h) | Speed @90 RPM (km/h) | Wheel Torque (N·m, Fp=200N) |
| 22 | 14 | 1.571 | 3.46 | 12.4 | 18.7 | 152.7 |
| 22 | 16 | 1.375 | 3.02 | 10.9 | 16.3 | 133.6 |
| 22 | 18 | 1.222 | 2.69 | 9.7 | 14.5 | 118.7 |
| 22 | 20 | 1.100 | 2.42 | 8.7 | 13.1 | 106.9 |
| 22 | 22 | 1.000 | 2.20 | 7.9 | 11.9 | 97.1 |
| 22 | 24 | 0.917 | 2.02 | 7.3 | 10.9 | 89.0 |
| 22 | 28 | 0.786 | 1.73 | 6.2 | 9.3 | 76.3 |
| 32 | 14 | 2.286 | 5.03 | 18.1 | 27.1 | 222.0 |
| 32 | 16 | 2.000 | 4.40 | 15.8 | 23.7 | 194.3 |
| 32 | 18 | 1.778 | 3.91 | 14.1 | 21.1 | 172.7 |
| 32 | 20 | 1.600 | 3.52 | 12.7 | 19.0 | 155.4 |
| 32 | 22 | 1.455 | 3.20 | 11.5 | 17.3 | 141.3 |
| 32 | 24 | 1.333 | 2.93 | 10.6 | 15.8 | 129.5 |
| 32 | 28 | 1.143 | 2.51 | 9.0 | 13.6 | 111.0 |
| 42 | 14 | 3.000 | 6.60 | 23.7 | 35.6 | 291.4 |
| 42 | 16 | 2.625 | 5.77 | 20.8 | 31.2 | 255.0 |
| 42 | 18 | 2.333 | 5.13 | 18.5 | 27.7 | 226.7 |
| 42 | 20 | 2.100 | 4.62 | 16.6 | 24.9 | 204.0 |
| 42 | 22 | 1.909 | 4.20 | 15.1 | 22.7 | 185.5 |
| 42 | 24 | 1.750 | 3.85 | 13.9 | 20.8 | 170.0 |
| 42 | 28 | 1.500 | 3.30 | 11.9 | 17.8 | 145.7 |

# Torque Range under Normal Cycling Conditions

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Condition | Pedal Force (N) | Crank Torque (N·m) | Wheel Torque Min Gear (22/28) | Wheel Torque Max Gear (42/14) |
| Casual Cycling | 100 | 17.0 | 38.2 | 145.7 |
| Strong Pedaling | 300 | 51.0 | 114.5 | 437.1 |