Simple Compound and Continuous Interest

Name: ____________	Date: ____________	Score: ______ / 33

Quick Review

Simple interest is the easy one: interest is computed on the principal only, never on previously earned interest. $I = Prt$ and $A = P + I = P(1 + rt)$. Each year earns the same dollar amount – the growth is linear.

Compound interest is where the magic lives. Interest earns interest. With n compounding periods per year, $A = P\left(1 + \frac{r}{n}\right)^{nt}$. The two moves to watch: divide the rate by n, multiply the exponent by n. Annual ($n = 1$), semiannual ($n = 2$), quarterly ($n = 4$), monthly ($n = 12$), daily ($n = 365$).

Continuous compounding pushes $n \to \infty$. The formula collapses to $A = Pe^{rt}$, where $e \approx 2.71828$. It's the upper limit – you can't beat continuous with any finite n.

Plug in r as a decimal, not a percent. A 5% rate is $r = 0.05$. Forgetting this is the most common error on the whole topic.

APR vs. APY. APR is the stated annual rate. APY is what you actually earn after compounding: APY $= (1 + r/n)^n - 1$. For continuous, APY $= e^r - 1$. APY is always at least as big as APR.

Solving for principal (present value): rearrange to $P = \dfrac{A}{(1 + r/n)^{nt}}$ or $P = Ae^{-rt}$. That tells you what to deposit *today* to hit a target A later.

Common slips. Using $r = 5$ instead of $r = 0.05$. Forgetting to divide the rate by n when compounding more than once a year. Forgetting to multiply t by n in the exponent. Mixing simple interest (linear) and compound interest (exponential) on the same problem – look at the wording carefully.

PRACTICE

Use simple, compound, or continuous interest as the problem describes. Use r as a decimal.

1. Simple interest. $P = \$1{,}000,\ r = 5\%,\ t = 3$. Find I. ________
2. Simple interest. $P = \$2{,}500,\ r = 4\%,\ t = 6$. Find A. ________
3. Compound annually. $P = \$1{,}000,\ r = 6\%,\ t = 2$. Find A. ________
4. Compound quarterly. $P = \$1{,}200,\ r = 2.4\%,\ t = 6$. Write the expression. ________
5. Continuous. $P = \$5{,}000,\ r = 3\%,\ t = 10$. Write the expression. ________
6. Value of e to 3 decimal places ________
7. Simple interest. $P = \$3{,}500,\ r = 4.2\%,\ t = 5$. Find A. ________
8. Three accounts each start with $\$2{,}000$ at 4% for 3 years. Using the table, find the balance in the *quarterly* account. ________

Account	Principal	Rate	Compounding	Years
Annual	$\$2{,}000$	4%	once a year	3
Quarterly	$\$2{,}000$	4%	$4\times$/year	3
Continuous	$\$2{,}000$	4%	continuous	3

9. This table tracks a $\$1{,}000$ deposit growing at 5% compounded annually. Use it to find the balance after year 4. ________

Year	0	1	2	3	5
Balance	$1,000.00	$1,050.00	$1,102.50	$1,157.63	$1,276.28

10. Continuous. $P = \$1{,}000,\ r = 6\%,\ t = 1$. Find A. ________
11. Solve $20{,}000 = P(1.05)^{10}$ for P. ________
12. APY for $r = 6\%$ compounded monthly ________

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13. APY for $r = 6\%$ compounded continuously ________

14. Simple vs. compound at $r = 5\%, t = 1, P = \$1{,}000$ ________

15. Compound annually. $P = \$800,\ r = 7\%,\ t = 5$. Find A. ________

16. Two banks compete for a $\$3{,}000$ deposit over 5 years. Using the table, which account ends with more, and by about how much? ________

Account	Principal	Rate	Compounding	Years
Bank A	$\$3{,}000$	5%	annual	5
Bank B	$\$3{,}000$	4.8%	monthly	5

17. Continuous formula: identify A, P, r, t in $A = Pe^{rt}$ ________

18. Compound quarterly. $P = \$4{,}000,\ r = 8\%,\ t = 2$. Find A. ________

19. Solve $A = Pe^{rt}$ for t (symbolic). ________

20. Simple interest. Find t when $P = \$2{,}000, r = 5\%, I = \$300$. ________

♦ Word Problems

21. A bank offers two investment options for a $\$10{,}000$ deposit held for 4 years. Option A pays 5.5% compounded annually; Option B pays 5.5% compounded continuously. How much more does Option B earn? Round to the nearest dollar. ____

22. A parent deposits $\$1{,}200$ into a college savings account that compounds quarterly at 2.4% per year. How much is in the account after 6 years? Round to the nearest cent. ____

23. An investor wants to have $\$20{,}000$ in an account after 10 years. The account earns 5% compounded annually. How much must be deposited today? Round to the nearest dollar. ____

24. A financial institution offers three plans for a $\$5{,}000$ investment held for 6 years: (I) simple interest at 4.5%, (II) compound interest at 4.2% compounded monthly, and (III) continuous compounding at 4%. Which plan yields the most, and what is the approximate amount? ____

Additional Practice

25. Simple interest on $\$800$ at 5% for 3 years. ________

26. Total after simple interest: $\$500$ at 4% for 2 years. ________

27. Compound amount: $\$1000(1.06)^2$. ________

28. Monthly payment total: $\$250$ for 48 months. ________

29. Markup: cost $\$40$, selling price $\$55$. ________

30. Discount: 20% off $\$75$. ________

31. Sale price after 20% off $\$75$. ________

32. Percent increase from 80 to 100. ________

33. Find tax at 7% on $\$60$. ________

Answer Keys

1. $150
2. $3,100
3. $1,123.60
4. $1200(1.006)^{24}$
5. $5000\,e^{0.30}$
6. 2.718
7. $4,235
8. ≈ $2,253.65
9. ≈ $1,215.51
10. ≈ $1,061.84
11. ≈ $12,278
12. ≈ 6.168%
13. ≈ 6.184%
14. Same: $1,050
15. ≈ $1,122.04
16. Bank A, by ≈ $17
17. amount, principal, rate, time
18. ≈ $4,686.64
19. $t = \frac{1}{r}\ln\left(\frac{A}{P}\right)$
20. 3 years
21. ≈ $73
22. ≈ $1,385.26
23. ≈ $12,278
24. Plan II ≈ $6,431

Additional Practice Answers

25. $120
26. $540
27. $1123.60
28. $12000
29. $15
30. $15
31. $60
32. 25%
33. $4.20

Additional Practice: Answers for all numbered items, including the added practice, are shown in the grid above.

Step-by-Step Explanations

1. Identify the pieces: $P = 1000$, $r = 0.05$ (the percent as a decimal), $t = 3$. Simple interest uses $I = Prt = 1000 \times 0.05 \times 3 = 150$. Each year earns the same $\$50$, so three years give $\$150$ – that flat, equal-each-year growth is exactly what makes simple interest linear rather than compounding.

2. Here $P = 2500$, $r = 0.04$, $t = 6$. First the interest: $I = Prt = 2500 \times 0.04 \times 6 = 600$, then the total amount $A = P + I = 2500 + 600 = 3100$. You can also fold it into one step with $A = P(1 + rt) = 2500(1 + 0.04 \times 6) = 2500(1.24) = 3100$. The question asks for A, the final balance, not just I – a common mix-up.

3. With $n = 1$ (annual), the formula $A = P(1+r/n)^{nt}$ becomes $A = P(1+r)^t$. Plug in $P = 1000$, $r = 0.06$, $t = 2$: $A = 1000(1.06)^2 = 1000 \times 1.1236 = 1123.60$. The first year earns $\$60$, but the second earns $\$63.60$ because that $\$60$ is now earning interest too – that extra $\$3.60$ is compounding in action.

4. Quarterly compounding means $n = 4$. Drop the pieces into $A = P(1+r/n)^{nt}$: the periodic rate is $r/n = 0.024/4 = 0.006$ and the exponent is $nt = 4 \times 6 = 24$, giving $1200(1.006)^{24}$. The two moves that trip people up are dividing the rate by n and multiplying t by n – do both or the answer is off.

5. Continuous compounding uses $A = Pe^{rt}$. With $P = 5000$, $r = 0.03$, $t = 10$, the exponent is $rt = 0.03 \times 10 = 0.30$, so $A = 5000e^{0.30}$. Leave it in exact form unless asked to evaluate – numerically it works out to about $\$6{,}749.29$. Note there's no r/n here; continuous skips the n entirely.

6. This is Euler's number, the base of continuous growth: $e \approx 2.71828\ldots$, which rounds to 2.718. Don't round it up to 3 – that's a tempting but costly slip, since it sits between 2 and 3 and shows up in every $A = Pe^{rt}$ calculation.

7. Name the pieces: $P = 3500$, $r = 0.042$, $t = 5$. Simple interest gives $I = Prt = 3500 \times 0.042 \times 5 = 735$, then add it back: $A = P + I = 3500 + 735 = 4235$. Because it's simple interest, each year adds the same $\$147$ – no compounding, so the same dollar amount every single year.

8. Read the quarterly row from the table: $P = 2000$, $r = 0.04$, $t = 3$, and quarterly means $n = 4$. So $r/n = 0.04/4 = 0.01$ and $nt = 4 \times 3 = 12$, giving $A = 2000(1.01)^{12} \approx 2000 \times 1.12683 = 2253.65$. For context, the annual account trails at $\$2{,}249.73$ and continuous leads at $\$2{,}254.99$ – once you're past yearly compounding, adding more periods barely moves the result.

9. The table jumps from year 3 to year 5, so year 4 is missing – but each year just multiplies by 1.05. Take the year-3 balance and step forward once: $1157.63 \times 1.05 \approx 1215.51$. (Or go straight from the start with $1000(1.05)^4 \approx 1215.51$.) Notice the yearly gains grow each year – that widening is compounding pulling ahead of a flat $50/year.

10. Continuous compounding is $A = Pe^{rt}$. With $P = 1000$, $r = 0.06$, $t = 1$, the exponent is just $rt = 0.06$, so $A = 1000e^{0.06} \approx 1000 \times 1.0618365 = 1061.84$. Keep the full value of $e^{0.06}$ in your calculator until the last step – rounding e early throws off the cents.

11. To undo the compounding, divide both sides by $(1.05)^{10}$: $P = \dfrac{20000}{(1.05)^{10}}$. Since $(1.05)^{10} \approx 1.62889$, $P \approx \dfrac{20000}{1.62889} \approx 12278$. This is present value – what you'd deposit today to land at $\$20{,}000$ in ten years at 5%. Notice it's well above half, since compounding does the rest of the work.

12. APY strips out the principal and asks what one year of compounding actually returns: $\text{APY} = (1 + r/n)^n - 1$. Monthly means $n = 12$, so $\text{APY} = (1 + 0.06/12)^{12} - 1 = (1.005)^{12} - 1 \approx 0.06168$, or 6.168%. That's the rate you'd need under plain annual compounding to match what monthly delivers – slightly above the 6% APR.

13. For continuous compounding, APY uses $e^r - 1$ instead of $(1 + r/n)^n - 1$. So $\text{APY} = e^{0.06} - 1 \approx 0.06184$, or 6.184%. This is the ceiling – pushing n to infinity, you can't beat it with any finite compounding frequency, though it only edges out monthly by a sliver.

14. For a single year with annual compounding, the two formulas collapse to the same thing: simple gives $P(1 + rt) = 1000(1.05) = 1050$ and compound gives $P(1 + r)^1 = 1000(1.05) = 1050$. They only diverge once $t > 1$ or $n > 1$, because that's when interest starts earning interest. After one year, there's nothing to compound yet.

15. Annual compounding uses $A = P(1 + r)^t$. With $P = 800$, $r = 0.07$, $t = 5$: $A = 800(1.07)^5 = 800 \times 1.40255 \approx 1122.04$. Work out $(1.07)^5$ fully before multiplying by 800 – rounding the growth factor early would cost you cents.

16. Compute each from the table. Bank A is annual ($n = 1$): $3000(1.05)^5 \approx 3828.84$. Bank B is monthly ($n = 12$): $r/n = 0.048/12 = 0.004$ and $nt = 60$, so $3000(1.004)^{60} \approx 3811.92$. The difference is about $3828.84 - 3811.92 = \$16.92$, so Bank A wins. The takeaway: Bank A's higher rate (5% vs. 4.8%) beats Bank B's more frequent compounding – the rate matters more than how often interest posts.

17. Read the formula left to right: A is the final amount you end with, P is the starting principal, r is the annual rate written as a decimal, and t is time in years.

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Labeling each variable before you plug in numbers prevents the classic mistake of swapping A and P or entering r as a percent.

18. Quarterly means $n = 4$, so $r/n = 0.08/4 = 0.02$ and $nt = 4 \times 2 = 8$. Then $A = P(1 + r/n)^{nt} = 4000(1.02)^8 \approx 4000 \times 1.17166 = 4686.64$. Watch both adjustments: divide the rate by 4 and use 8 periods, not 2 years, in the exponent.

19. Isolate the exponential first by dividing both sides by P: $A/P = e^{rt}$. Take the natural log of both sides to undo the e, since $\ln$ is the inverse of e^x: $\ln(A/P) = rt$. Finally divide by r to get $t = \frac{1}{r}\ln(A/P)$. Use $\ln$, not $\log$ base 10 – base e needs its matching log.

20. Start from $I = Prt$ and solve for t by dividing by Pr: $t = \frac{I}{Pr}$. With $I = 300$, $P = 2000$, $r = 0.05$, the denominator is $Pr = 2000 \times 0.05 = 100$, so $t = \frac{300}{100} = 3$ years. Since the interest is $\$100$ a year, $\$300$ takes exactly three years.

21. Annual: $A = 10{,}000(1.055)^4 \approx 10{,}000 \times 1.23882 = 12{,}388.25$. Continuous: $A = 10{,}000\, e^{0.055 \cdot 4} = 10{,}000\, e^{0.22} \approx 10{,}000 \times 1.24608 = 12{,}460.77$. Difference: $12{,}460.77 - 12{,}388.25 \approx 72.52$, which rounds to about $\$73$. Continuous beats annual at the same nominal rate, but the gap is small – compounding frequency stops mattering much once you're past monthly.

22. Start by naming the pieces: $P = 1200$, the annual rate is $r = 0.024$ (write the percent as a decimal), $n = 4$ since quarterly means four periods a year, and $t = 6$. The periodic rate is $r/n = 0.024/4 = 0.006$ and the number of periods is $nt = 4 \times 6 = 24$, so $A = 1200(1.006)^{24}$. Computing $(1.006)^{24} \approx 1.15439$ gives $A \approx 1200 \times 1.15439 \approx 1385.26$. The biggest slip here is using $r = 2.4$ instead of 0.024, or forgetting to divide the rate and multiply the exponent by n.

23. This is a present-value problem. Solve $A = P(1 + r)^t$ for P: $P = \frac{A}{(1+r)^t} = \frac{20{,}000}{(1.05)^{10}}$. Computing $(1.05)^{10} \approx 1.62889$, $P \approx \frac{20{,}000}{1.62889} \approx 12{,}278$. So just over twelve grand today buys twenty grand in a decade. (The tempting wrong answer is $\$10{,}000$ – the half – which ignores compounding entirely.)

24. Compute all three. Plan I (simple): $A = 5000(1 + 0.045 \cdot 6) = 5000(1.27) = 6{,}350$. Plan II (monthly compound): $A = 5000(1 + 0.042/12)^{12 \cdot 6} = 5000(1.0035)^{72} \approx 5000 \times 1.28617 \approx 6{,}431$. Plan III (continuous): $A = 5000\, e^{0.04 \cdot 6} = 5000\, e^{0.24} \approx 5000 \times 1.27125 \approx 6{,}356$. The ranking is II $>$ III $>$ I, so Plan II at about $\$6{,}431$ wins. The lesson: a slightly higher rate (with monthly compounding) beats continuous at a lower rate – the rate itself matters more than the compounding frequency.

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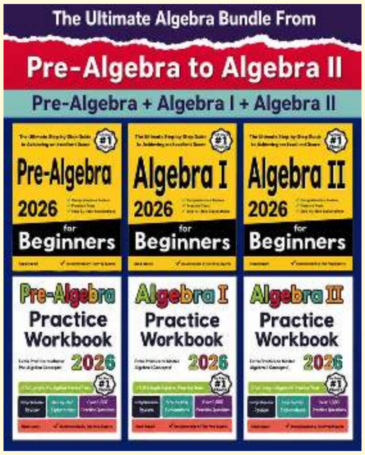

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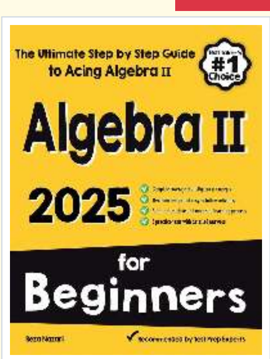

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