



# Banking Interviews Guide

## I. Intro

The Investment Banking (IB) interview process is highly competitive and designed to rigorously filter out potential candidates. Consequently, answering the behavioral, technical, and logical questions that are asked in the interview with proven answers that we provide is key to converting an interview into an offer.

The following IB interview guide is a comprehensive tool designed to cover every single aspect of the interview process, guiding you from the very beginning to the very end.

## II. Common First Investment Banking Interview Questions: Crafting Your Story

### 1. Walk me through your background/resume

Dial-in a cohesive 90-second resume walkthrough that focuses on the positive and motivating factors behind every transition (school to job, job to better job, most recent job to grad school). Be deliberate. Every move you made should have a reason (preferably that you initiated). Don't be negative. Never say you left because you were bored or "wanted to try something new."

### 2. Why investment banking?

The answer to this question should be tailored uniquely to you and to the firm you are interviewing with. While answering this question, it is key to capitalize on your previous professional/leadership experience, highlight it and create a logical path as to why you are now trying to break into investment banking.

## III. 15 Common Investment Banking Technical Questions

### 1. What are the three main financial statements?

Sample Answer:

The three main financial statements are:

- Income Statement
- Balance Sheet
- Statement of Cash Flows

The Income Statement discloses a company's revenues and expenses, which together yield net income over a period of time. The Balance Sheet discloses a company's assets, liabilities, and equity on a specific date. The Cash Flow Statement starts with net income from the Income Statement; then adjusts for non-cash expenses, non-operating expenses like capital expenditures, changes in working capital, or debt repayment and issuance, to arrive at the company's closing cash balance.



## 2. How are the three main financial statements connected?

### Sample Answer:

Net income flows from Income Statement into the Cash Flow Statement (CFS) as Cash Flow from Operations. Net income less dividends are added to retained earnings from the prior period's Balance Sheet (BS) to come up with retained earnings as on the date of the current period's BS. The opening cash balance on the CFS is from the prior period's Balance Sheet while the closing cash balance on the CFS is the balance on the current period's Balance Sheet."

## 3. If you could use only one financial statement to evaluate the financial state of a company, which would you choose?

### Sample Answer:

The cash flow statement because it shows the actual liquidity of the company and how it is generating and using cash. The balance sheet just shows a snapshot of the company at a point in time, without showing the performance of the company, and the Income statement has several non-cash expenses that may not be affecting the company's health and can be manipulated. Overall, the key to a great company is generating significant cash flow and having a healthy cash balance, both of which are disclosed in the CF statement.

## 4. How would a \$10 increase in depreciation expense affect the three financial statements (assuming a 40% tax rate)?

### Sample Answer:

In the income statement, the depreciation increase of \$10 is set off by a reduction of \$4 on taxes as depreciation is a tax-deductible expense for the net reduction in net income of \$6. In the cash flow statement, net income is reduced by \$6, depreciation is increased by \$10, net cash from operations and total cash is increased by \$4. This increase in cash is because depreciation is a non-cash expense that has no impact on cash while the reduction in taxes affects the cash flow. In the balance sheet, property, plant, and equipment balances reduce by \$10, cash balance increases by \$4, and retained earnings reduce by \$6 due to the reduction in net income.

The following points summarise this:

### **On the income statement**

- \$10 depreciation expense, 40% tax rate
- Reduction in net income of  $\$10 \times (1 - 40\%) = \$6$

### **Reduction in net income flows to cash from operations**

- Net income reduced by \$6
- Depreciation increases by \$10
- Net increase in cash from operations of \$4
- Ending cash increases by \$4



### Ending cash flows onto the balance sheet

- Cash increases by \$4
- Property, plant, and equipment lose \$10 in value
- Net decrease in assets of \$6, matches the net drop in shareholder equity due to the reduction of retained earnings from the \$6 is net income

## 5. "Walk me through the Income Statement"

### Sample Answer:

The first line of the Income Statement represents revenues or sales. From that, we subtract the cost of goods sold, which gives gross margin. Subtracting operating expenses from gross margin gives us operating income (EBIT). We then (add/subtract) interest expense (income), taxes, and other expenses (income) to arrive at Net Income.

## 6. What is Enterprise Value?

### Sample Answer:

Enterprise Value (EV) is the value of an entire firm, both debt, and equity. This is the price that would be paid for the company in the event of acquisition without a premium.

$$EV = \text{Market Value of Equity} + \text{Debt} + \text{Preferred Stock} + \text{minority interest} - \text{Cash}$$

## 7. What is WACC and how do you calculate it?

### Sample Answer:

WACC is the acronym for Weighted Average Cost of Capital. It reflects the overall cost for a company to raise new capital, which is also a representation of the riskiness of investment in the company (higher the risk, higher the cost of capital). It is commonly used as the discount rate in a discounted cash flow analysis to calculate the present value of a company's cash flows and terminal value.

## 8. What is EBITDA?

### Sample Answer:

EBITDA stands for Earnings before Interest, Taxes, Depreciation, and Amortization. It gives us a good idea of a company's profitability and is a quick metric for free cash flow because it will allow you to determine how much cash is available from operations to pay interest, CAPEX, etc.

$$EBITDA = \text{Revenue} - \text{Expense (except depreciation and amortization)}$$

It is also often used for rough valuations in a comparable company or precedent transaction analysis as part of the EV/EBITDA multiple.



## 9. Would you be calculating enterprise value or equity value when using a multiple based on free cash flow or EBITDA?

### Sample Answer:

EBITDA and free cash flow represent cash flows that are available to repay holders of a company's debt and equity, so a multiple based on one of those two metrics would describe the value of the whole business from the perspective of all its investors.

A multiple such as the P/E ratio, based on earnings alone, represents the amount available to common shareholders after all expenses are paid, using which you would be calculating the value of the firm's equity.

## 10. Can a company have a negative book equity value?

Book equity value is the accounting value of equity derived by subtracting the value of a company's liabilities from its total assets. It is the total shareholder's equity, an amount shown as "Total Equity" in the Balance Sheet of the company.

### Sample Answer:

Yes. If there are large cash dividends or if the company has been operating at a loss for a long time.

## 11. What is typical of an LBO (leveraged buyout) transaction?

A firm (usually a PE firm) uses a high amount of debt (70 - 90%) to finance the purchase of a company, then uses the company's cash flows to pay off that debt over time.

The acquired company's assets may be used as collateral. Ideally, the original debt of the acquired company would have been partially retired at the time of exit.

In the context of a private equity investment, the debt acts as a way to magnify returns (boost IRR for the fund), but it can also backfire if the acquisition turns south.

## 12. Why would a company issue equity rather than debt to fund its operations?

### Sample Answer:

There are many reasons why a company would want to issue equity instead of debt. Some of them are:

- If the company feels its stock price is inflated, it can raise a relatively large amount of capital with comparatively minimal dilution to existing shareholders.
- If the projects the company is looking to invest in do not produce immediate or consistent cash flows to pay its debt.



- If the company wants to adjust the cap structure or pay down debt.
- If the owners of the company want to sell off a portion of their ownership.

### 13. How is it possible for a company to have a positive net income but go bankrupt?

#### Sample Answer:

This is possible if working capital erodes (such as increasing accounts receivable, lowering accounts payable, lower inventory turnover) or the company is growing so fast that it's unable to raise enough capital to fund operations. Another possibility is the existence of financial fraud.

### 14. What are some ways you can value a company?

#### Sample Answer:

The three most common ways of valuing a company are:

**Comparable companies or multiples analysis:** This is the most common way to value a company. This method attempts to find a group of companies that are comparable to the target company and to work out a valuation based on what they are worth. The idea is to look for companies in the same sector and with similar financial statistics (Price to Earnings, Book Value, Free Cash Flow, EBITDA, etc) and then assume that the companies should be priced relatively similarly.

**Market valuation or market capitalization:** In this method, the market value of equity is used and hence can only be used for publicly traded companies. It is calculated by multiplying the number of shares outstanding by the current stock price.

**Discounted cash flow analysis:** This method involves calculating the sum of the present values of all future cash flows to give the value of the entire company including debt and equity, which is also called enterprise value.

### 15. Which of the valuation methodologies will result in the highest valuation?

Here is a list of the four valuation methodologies organized from highest valuation to lowest valuation:

- **Precedent Transaction** - Since a company will pay a control premium and a premium for synergies coming from the merger, values tend to be high.
- **Discounted Cash Flow** - Those building the DCF model are frequently optimistic in their projections.
- **Market Comps** - Based on other similar companies and how they are trading in the market. No control premium or synergies.
- **Market Valuation** - Based on how the target is being valued by the market. Just equity value, no premiums or synergies.



## 14 Bank-Specific Hard Technical Questions

### 1. Walk me through a Leveraged Buyout (LBO) Model.

At a high level, there are 5 steps to an LBO:

1. Calculate the total acquisition price, including the acquisition of the target's equity, repayment of any outstanding debt, and any transaction fees (such as the fees paid to investment banks and deal lawyers, accountants, consultants, etc.)
2. Determine how that total price will be paid, including:
  - Equity from the PE sponsor,
  - Roll-over equity from existing owners or managers,
  - Debt, seller financing, etc.
3. Project the target's operating performance over ~5 years and determine how much of the debt principal used to acquire the target can be paid down using the target's FCF over that time.
4. Project how much the target could be sold for after ~5 years in light of its projected operating performance; Subtract any remaining net debt from this total to determine projected returns for equity holders.
5. Calculate the projected IRR and MoM return on equity based on the amount of equity originally used to acquire the target and the projected equity returns upon exit.

### 2. What might cause a company's Present Value (PV) to increase or decrease?

Factors that may cause a company's PV to increase:

- An increase in cash flow causes an increase in future value (FV)
- An increase in the growth rate of future cash flows

Factors that may cause a company's PV to decrease:

- Increased discount rate
- Delay in receiving future cash flows
- Reduction in the growth rate of future cash flows

### 3. How would a significant event impact financial markets?

Sample Answer 1: The COVID-19 Delta Variant is predicted to cause an upsurge in total worldwide cases, therefore volatility would increase within the stock market as speculating investors debate the impact of the variant. This may cause a runover effect with the Federal Reserve System keeping interest rates low moving forward.

Sample Answer 2: The Nigerian election takes place in February. Four years ago, President Muhammadu Buhari gained power on a surge of optimism, pledging to restore security and end corruption. His Presidential record has been mixed, and his popularity and health have declined (he recently denied rumors of being replaced by a body double). The old regime may regain political power, impacting the free flow of goods through the country.



#### 4. How do interest rates affect the market?

An increase in the interest rates will affect the cost of borrowing for companies. This means a lesser amount of funding from banks, which leads to companies having slower growth on average as compared to before the interest rate hike.

The higher cost of borrowing will also affect DCM. I would expect companies to issue fewer bonds or maintain the same capital structure but cut back on other expenses e.g. layoffs. Given the slower growth of companies, I would expect lesser interest from investors on IPOs. The slower growth and low valuations will then lead to an increase in M&A by strategics. On the other hand, the higher cost of borrowing might reduce the amount of leveraged M&A activity at the same time.

Overall, I feel that the increase in interest rates will affect M&A and capital markets negatively, and thus hiring will be down next year.

#### 5. Are there any special multiples that only apply to some industries or sectors?

Examples of industry-specific multiples are:

- Retail or Airlines: EV / EBITDAR (Earnings Before Interest, Taxes, Depreciation, Amortization & Rental Expense)
- Energy: EV / EBITDAX (Earnings Before Interest, Taxes, Depreciation, Amortization & Exploration Expense), EV / Daily Production, EV / Proved Reserve Quantities
- Technology (Internet): EV / Unique Visitors, EV / Page views

#### 6. If there was an earthquake in a country, what would happen next year to the country's GDP growth compared to the year of the earthquake?

An earthquake would cause the country's GDP to immediately decline sharply due to the immediate effects of the earthquake as a lot of productive resources may be put out of use. But then the GDP growth will start to increase to an above-average level as there would be an increased amount of spending on rebuilding the infrastructure.

#### 7. Can a company have a negative book value?

Yes, a company could have a negative book equity value if the owners are taking out large cash dividends or if the company has been operating for a long time at a net loss, leading to the company having to take on debt to fund loss of cash. Eventually, equity can be negative implying that the entire operation is funded by debt.

#### 8. What is risk?

This question is a lot more broad, giving you a lot of room to work with. A common method of answering this question would be bringing up 2-3 different types of financial risk concepts, giving a straight definition as to what they are, and following up with an example to demonstrate applied understanding.

There are many different types of risks that businesses, and individuals alike, experience. Some examples of these risks would be:



**Credit Risk** - This is the risk of a possible loss being incurred by a business or an individual, should their borrower fail to repay a loan or meet contractual obligations. It is impossible to quantify credit risk and precisely predict which borrowers will default on loans, but there are risk management teams built to minimize a business' risk and manage their credit exposure. An example of credit risk would simply be a bank lending a citizen a loan of \$100,000 to start their business as an entrepreneur, on which the bank incurs the risk of not having the loan repaid should the citizen's business go bankrupt.

**Interest Rate Risk** - This is the risk incurred where there may be a reduction in the value of investment assets should the interest rate environment change drastically in a short period. An example of this would be that if interest rates increased, the value of fixed-income investments would decrease.

## 9. How do you calculate Terminal Value?

Terminal Value or TV is the value of any investment at the end of the investment period. This will usually assume a constant growth rate into the future. It can be calculated by applying an exit multiple to the company's last projected year's EBITDA, EBIT, or Free Cash Flow (multiples method). Alternatively, the Gordon Growth method can be used to estimate TV based on its growth rate into perpetuity.

The formula for calculating TV without accounting for growth is:  
$$\text{Expected cash flow} / (1 + \text{Required rate of return})^{\text{Time}}$$

The formula for calculating TV using Gordon Growth is:  
$$\text{Terminal Value} = \text{Expected dividend} / (\text{Required rate of return} - \text{Growth rate}).$$

## 10. What does an investment banking division do?

The investment banking division is sometimes referred to as corporate finance and is broadly split into 2 sectors, products and industries. The purpose of both is to provide advisory on transactions, mergers, and acquisitions and to arrange (and sometimes even provide) financing for these transactions.

Investment banking product groups are broken down into:

- Mergers and Acquisitions (M&A): Advisory on sale, merger, and purchase of companies.
- Leveraged Finance (LevFin) - Issuance of high-yield debt to firms to finance acquisitions and other corporate activities.
- Equity Capital Markets (ECM) - Advice on equity and equity-derived products (IPOs, shares, capital raises, secondary offerings, etc.)
- Debt Capital Markets (DCM) - Advice on raising and structuring debt to finance acquisitions and other corporate activities.
- Restructuring – Improving the structures of a company to make it more profitable or efficient.

## 11. If a REIT is trading below NAV, what strategic options would you provide them as a banker?

M&A seems to be off the table because REITs have low cash balances and can't do stock issuances because they would be dilutive. Therefore, my advice would be to basically sell assets in non-core markets to raise cash.



**12. Walk me through the full maths for the deal now. Assume that Company A has 10 shares outstanding at a share price of \$25.00, and its Net Income is \$10. It acquired Company B for a Purchase Equity Value of \$150. Company B has a Net Income of \$10 as well.**

Company A's EPS is  $\$10 / 10 = \$1.00$ .

To complete the deal, Company A must issue 6 ( $\$150 / \$25.00$ ) new shares which means that the combined share count after the deal is 16 ( $10 + 6$ ).

Since no cash or debt was used and the tax rates are the same and the combined net income = Company A net income + Company B net income =  $\$10 + \$10 = \$20$ .

The Combined EPS, therefore, is  $\$20 / 16 = \$1.25$ , which is an increase of 25% in the EPS, and this is what is called accretion.

**13. Company A is acquiring Company B; firm A has a stock price of \$10/share, B's share price is \$20/share. A has a \$4 Cash Flow (CF)/share and B \$8 CF/share; is the deal accretive or dilutive if the transaction was all-stock?**

Thinking of cash flow/share the same way as earnings per share, the PE for A is 2.5 and B is 2.5. As both their EPS are equal, the transaction is neither accretive nor dilutive.

**14. Company A has an Enterprise Value (EV) of \$1B, an EBITDA of \$200M and is leveraged 2.5x wants to buy company B which has EBITDA of \$100M; A will finance the acquisition with \$250M debt; how does this transaction affect leverage?**

You need to remember that the leverage multiple stands for Debt/EBITDA; so calculating out the leverage multiples, you will see both A and B are leveraged at 2.5, hence, the combined leverage multiple of A and B is still 2.5; if the transaction is equity-financed, the leverage would decrease and the company would be de-leveraged; deals are usually more accretive with debt due to tax deduction on interest expense.



# Interview Brainteasers

## Market Sizing

The hack to answering any market sizing questions in the most straightforward manner is coming up with an overall equation that will lead to your answer. Then walk through that single-lined equation with the interviewer while remembering to round numbers to make them convenient to use. Within that single line equation you come up with, it is also useful to find one component that can be disaggregated e.g. lovers vs haters of oat milk or wealthy vs poor households as demonstrated below.

### 1. What is the UK market size of oat milk in revenue per year for the UK?

The overall equation: **Oat milk revenue per year = #People in the UK \* Quantity per person per year \* Cost per unit.**

[I] *Number of people in the UK.*

Disaggregating one of the variables is key to showing your ability and thinking in a more comprehensive manner.

E.g. #people in this case (disaggregated based on their regularity of use), or it could be #mattresses (large family homes, small family homes, hotels, hospitals), #pigs in a country (food, medicines, lard, leather).

Disaggregate the ~65m people in the UK into 3 estimated segments.

- [a] People that never use oat milk; 45m
- [b] People that occasionally use oat milk; 15m
- [c] Oat milk lovers; 5m

[II] *Quantity per person (follows on from disaggregation).*

- [a] 0ml per day
- [b] 50ml per day  $\times$  360 days = 18litres per year. Round to 20litres. 20litres  $\times$  15m = **300m litres.**
- [c] Oat milk lovers might drink 4x segment b's amount. 20litres  $\times$  4 = 80 litres per year. 80 litres  $\times$  5m = **400m litres.** This 200ml consumed by oat milk lovers might involve 150ml in cereal and another 50ml in coffee per day.

Total population consumption = 300m + 400m = 700m litres per year

[III] Finding revenue per year.

Cost of a litre of almond milk  $\sim$  £1

Oat milk revenue per year = 700m  $\times$  £1 = £0.7bn

The beauty of this approach is that if you want to, you can dig deeper into each respective component and add more complexities but this is not usually necessary for investment banking interviews.

### 2. How many electric cars are there in China?

**#Electric cars in China = #households \* cars per household \* cars that are electric**  
**Number of households**



The number of households in China can be found by dividing the total population by the number of people per household.

#Households =  $1.5\text{bn} / 3$  (total population divided by average people per household)

#Households =  $\sim 500\text{m}$

It is important to justify your assumptions so in this case, you could say that three people per household balances single residence households with families that live alongside grandparents or couples that have more than one child in China considering the one-child policy has now been dropped.

### **Cars per household**

This is an opportunity to disaggregate cars per household into household wealth brackets. Where 'w.' denotes wealth and 'c.' denotes the number of cars for that segment:

Cars per household =  $\%w.\text{low} * c.\text{low} + \%w.\text{med} * c.\text{med} + \%w.\text{high} * c.\text{high}$

Let's assume low wealth households have no cars and constitute 50% of the population, medium wealth households have one car per household and constitute 40% of the population, while the high wealth households have two cars each and constitute the final 10% of the population.

Cars per household =  $0.5 * 0 + 0.4 * 1 + 0.1 * 2 = 0.6$

For simplicity, it's worth simplifying this to 0.5 cars per household.

### **The proportion of cars that are electric**

This is another opportunity to disaggregate cars into 2nd hand and new cars although due to the pressure of interviews, disaggregating just one of the components is usually enough. Let's assume that 80% of the cars in China are bought 2nd hand while 20% are newly made with none of the 2nd hand cars being electric but 10% of the new cars being electric.

Proportion electric =  $\%[2\text{nd hand}] * \%[2\text{nd electric}] + \%[new] * \%[new electric]$

Proportion electric =  $0.8 * 0.0 + 0.2 * 0.1$

Based on these assumptions, the proportion of total cars that are electric = 0.02

### **Bringing it all together**

#Electric cars in China =  $500\text{m} * 0.5 * 0.02 = 500\text{m} * 0.01 = 500\text{m} * (1/100)$

So approximately 5m of the cars in China are electric.

## **3. How many Mattresses are sold in the US?**

#Mattresses sold in US =  $(\#households * \text{mattresses per household} + \#hotels * \text{mattresses per hotel}) * \%replaced$ .

The third and final country in this series of examples centres around the US, which has a population of about 330 million people.



For a consulting interview, you may be given a lot more time and therefore go into more detail, but considering you may only get a minute to think about this during an investment banking interview, balancing simplification with some thoughtful disaggregating factor is key (in this case we'll disaggregate homes and hotels).

### **Number of households**

There are roughly 330m people in the USA, and assuming an average household size of three:

$330\text{m}/3=110\text{m}$  which can be rounded down to 100m

### **Number of mattresses per household**

Assuming two of the three people in each household share a mattress (as a couple), we can say there are two mattresses per household.

### **Number of hotels**

For simplicity, we focus on hotels for alternative mattress use. Assuming there is one hotel per 20 households, we can say there are around 50,000 hotels in the US.

### **Number of mattresses per hotel**

This component seems to offer a good opportunity for disaggregation so we might split up hotels into small, medium and large categories like the following:

- 50% being small hotels that have 50 beds.
- 40% being medium hotels that have 500 beds.
- 10% being large hotels that have 2000 beds

So #mattresses per hotel  $=0.5*50+0.4*500+0.1*2000=25+200+200=425$  which we can round down to 400.

### **Percentage of mattresses replaced each year**

Assuming mattresses have a lifespan of 10 years, we can say that 10% of mattresses in the US will be replaced per year.

$$\text{\#Mattresses sold in US} = (100\text{m}*2+50\text{k}*400)*(1/10)$$

To simplify the calculation above, especially if you are not given a piece of paper, first divide the 100m and 400 by 10:

$$=10\text{m}*2+50\text{k}*40=20\text{m}+2\text{m}=22\text{m} \text{ mattresses bought in the US per year.}$$

A final technique is to say if given more time, I would also consider hospital beds and mattresses used in caravans among other details.

## **Calculations with Multiple Steps**

### **4. You have a tap with a 300ml and 500ml cup. How do you get exactly 400ml of water?**

Fill the 300ml cup and pour it into the 500ml cup. Then refill the 300ml and pour into a 500ml cup until it's full. That leaves 100ml in the 300ml cup and 500ml in the 500ml cup. Empty the 500ml cup and pour the 100ml from the 300ml cup into the 500ml cup.

Then refill the 300ml cup and pour it into the 500ml cup. Voila – you have 400ml.



## 5. Imagine you have a large cube structure made up of mini cubes ( $10 \times 10 \times 10 = 1000$ cubes). Then imagine that this large cube is dipped into red paint so that everything except the top layer is covered. How much is covered in red?

First we should calculate how many squares are in the inner layer of the massive cube:  
 $8 \times 8 \times 8 = 64 \times 8 = 60 \times 8 + 4 \times 8 = 480 + 32 = 512$

Now,  $1000 - 512 = 1000 - 512 = 488$  is on the outside.

So  $488 - 8 \times 8$  (top side not covered in red)  $= 488 - 64 = 424$  that get stained in red.

This leads to another point: **do not get too confident**. Communicate your calculations clearly otherwise you'll slip up. You might be comfortable in your chair at the moment reading this, but when your heart is racing faster than normal in that interview, you need to keep humble and thorough.

## 6. What is the reflex angle between the handles of a clock at 3:30pm?

The key to this question is realising that the hour hand moves one half the way between three and four by the time the clock reads 3:30pm. There are 12 hours on the face of the clock and  $360 \text{ degrees} / 12 = 30 \text{ degrees}$  so the hour hand would have moved 15 degrees.

Acute angle between hands at 3:30pm  $= 90 - 15 = 75$

Therefore reflex angle  $= 360 - 75 = 285 \text{ degrees}$ .

## 7. Four interns from different companies need to cross a bridge that only has space for two people at once to get to the club on time...

...They have one flashlight and 14 minutes to get there before their queue jump expires. The quant trader and consultant can cross in 1 minute, the asset manager can cross in 5 minutes and the investment banker can cross in 10 minutes. How can they make it before their queue jump expires in time for the club?

The quant trader and consultant cross first (1 minute total), before the quant trader returns (2 minutes), passing the flashlight to the asset manager and investment banker who walk across (12 minutes) before they pass it to the consultant who walks back (13 minutes) and returns with the quant trader (14 minutes).

## Mental Maths



## 8. What is $64 \times 98$ ?

$$64 \times 90 = 60 \times 90 + 4 \times 90 = 5400 + 360$$

$$5400 + 360 = \mathbf{5760}$$

$$64 \times 8 = 60 \times 8 + 4 \times 8 = 480 + 32$$

$$480 + 32 = \mathbf{512}$$

$$\mathbf{5760 + 512 = 6272}$$

## 10. How many times do the hands of a clock overlap in a day?

As if looking at the clock and two hands as a race from the start till the end of the day: we start at midnight where the number of overlaps is zero and the minute hand makes its first round. The hands overlap once the minute hand reaches 1:05. Then it overlaps again when the time reaches 2:10. As you can see, it's not as simple as overlapping 24 times because more than  $1/12$ th of the day has passed by the time there have only been two overlaps.

You may quickly see that 5 minutes is accumulated after one hour (before the overlap takes place), so after 12 hours, 60 minutes extra would have accumulated before the overlap takes place. Via the same logic, by 24 hours, 120 minutes would have accumulated before the final overlap takes place. So when the experiment is cut off at midnight the next day, only 22 overlaps would have been reached since the minute's hand has outpaced the starting position overlap by two hours.

Alternatively, you could calculate this algebraically: in  $T$  hours, the minute's hand would complete  $T$  laps round the clock. In  $T$  hours, the hour's hand would complete  $T/12$  laps round the clock. For the first overlap of the hands, the minute hand would have lapped the hour hand by one round of the clock. For the second time they overlap the minute's hand would have overlapped the hour's hand by two rounds of the clock.

In a more general form, for the  $N$ th time they overlap, the minute's hand would have overlapped the hour's hand by  $N$  rounds of the clock. So  $T = T/12 + N$

Setting  $T=24$  which is when the 'race' ends at midnight, 24 hours from the start, we can find  $N$ , the number of overlaps, as:

$$24 = 24/12 + N$$

$$24 = 2 + N$$

$$N = 22$$