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FORMULA SHEET

FRM Part I

GARP · Financial Risk Manager · Complete formula reference

84 formulas   4 subject areas

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HOW TO USE THIS SHEET

FRM Part I is a 100-question, four-hour multiple-choice exam covering four books. It is a breadth exam: the questions are rarely deep, but they come from everywhere, and the pass mark is set by how you perform against the cohort — not against a fixed score.

This sheet is organised by the four books, in GARP's own order. Use it to compress a topic AFTER you have studied it, not to learn one from scratch.

Two things separate FRM from CFA. First, notation matters — GARP uses continuous compounding almost everywhere, so e^(rT) and not (1 + r)^n. Second, the exam is heavily calculation-weighted; you are expected to produce numbers under time pressure with an approved calculator.

The ‣ notes flag what the question is really testing: a sign, a convention, an assumption that quietly breaks. Those are where the marks leak.

FOUNDATIONS OF RISK MANAGEMENT · 12 formulas

Book 1. Risk-adjusted performance, factor models and the vocabulary of enterprise risk. Roughly 20% of the exam.

Expected loss

$$EL = PD \times LGD \times EAD$$

Where: PD = probability of default, LGD = loss given default, EAD = exposure at default.

‣ *The single most important identity in the whole FRM programme. Expected loss is a COST — it is provisioned for and priced into the spread. Capital is held against UNexpected loss, not this.*

CAPM expected return

$$E[R_i] = R_f + \beta_i(E[R_m] - R_f)$$

Where: β_i = asset beta.

‣ *Only systematic risk is compensated. The entire premise is that idiosyncratic risk can be diversified away for free, so nobody pays you to bear it.*

Beta of an asset

$$\beta_i = Cov(R_i, R_m) / \sigma^2_m$$

Where: Covariance with the market over market variance.

‣ *A volatile asset with low market correlation has a LOW beta. High σ does not imply high β — this catches candidates every sitting.*

Jensen's alpha

$$\alpha = \bar{R}_p - [R_f + \beta_p(\bar{R}_m - R_f)]$$

Where: Realised return minus the CAPM-required return.

‣ *Measured in return units, so it cannot be compared across portfolios of different risk. Positive alpha means the manager beat what their beta entitled them to.*

Treynor ratio

$$T = (R_p - R_f) / \beta_p$$

Where: Excess return per unit of systematic risk.

‣ *Preferred over Sharpe for ranking well-diversified SUB-portfolios, where idiosyncratic risk has already been diversified away at the aggregate level. Sharpe is right when the portfolio stands alone.*

CDS spread approximation

$$s \approx PD \times LGD$$

Where: LGD = 1 − recovery rate.

‣ *The spread compensates you for expected loss per year. Invert it and you get the market-implied hazard rate — the same idea reappears in Part II credit.*

Annual CDS premium payment

$$\text{Premium} = s \times N$$

Where: s = spread in decimal, N = notional protected.

▸ *A 250 bp spread on $800M notional is $20M a year. Watch the units: spreads are quoted in basis points and notionals in millions.*

Risk-adjusted return on capital

$$\text{RAROC} = \text{Risk-adjusted return} / \text{Economic capital}$$

Where: Numerator is net of expected loss and funding costs; denominator is the capital allocated.

▸ *The bank's internal hurdle: an activity creates value only when RAROC exceeds the cost of equity. Expected loss belongs in the NUMERATOR (as a cost), not the denominator.*

Factor model return decomposition

$$R_i = E[R_i] + \beta_{i,1}f_1 + \dots + \beta_{i,k}f_k + \varepsilon_i$$

Where: f_k = zero-mean factor surprise, ε = idiosyncratic noise.

▸ *Factors have zero MEAN by construction — they are surprises, not levels. Diversification kills the ε term but leaves the factor exposures untouched, which is why factor risk is the risk that survives.*

APT multifactor expected return

$$E[R_i] = R_f + \beta_{i,1}\lambda_1 + \dots + \beta_{i,k}\lambda_k$$

Where: λ_k = risk premium per unit of exposure to factor k.

▸ *APT rests on no-arbitrage, not on a market portfolio — that is its advantage over CAPM. Its weakness is that it never tells you what the factors are.*

Fama-French three-factor model

$$E[R_i] - R_f = \beta_{i,M}(R_M - R_f) + \beta_{i,SMB}\cdot SMB + \beta_{i,HML}\cdot HML$$

Where: SMB = small minus big (size), HML = high minus low book-to-market (value).

▸ *A manager whose alpha vanishes once size and value are added was selling factor beta at active fees. Carhart adds momentum as a fourth factor.*

Firm-wide economic capital aggregation

$$\sigma^2_{firm} = \Sigma\sigma_i^2 + 2\Sigma_{i<j}\ \rho_{ij}\sigma_i\sigma_j$$

Where: σ_i = standalone economic capital of silo i, ρ_{ij} = correlation between silos.

▸ *Because correlations are below 1, total firm capital is LESS than the sum of the silos. That difference is the diversification benefit — and how it gets allocated back to business units is a genuine political fight inside banks.*

EXAM TIPS — FOUNDATIONS OF RISK MANAGEMENT

- EL versus UL is the organising idea of the whole qualification. Expected loss is priced and provisioned. Unexpected loss is what capital exists to absorb. Stress loss is what kills you anyway.
- Know the risk taxonomy cold — market, credit, liquidity, operational, business, strategic — and be able to place a scenario in the right box. GARP asks this directly.
- The case studies (Barings, LTCM, Metallgesellschaft, Société Générale) are examinable and they are free marks. Learn the ONE lesson each one teaches.

QUANTITATIVE ANALYSIS · 23 formulas

Book 2. Probability, regression, time series and machine-learning basics. Dense, and the foundation for everything in Part II.

Bayes' rule

$$P(A|B) = P(B|A) \times P(A) / P(B)$$
$$P(B) = P(B|A)P(A) + P(B|A^c)P(A^c)$$

Where: P(A) = prior, P(A|B) = posterior.

▸ *Build the denominator with the law of total probability first. Nearly every Bayes error is a bad denominator, not a bad concept.*

Law of total probability

$$P(B) = P(B|A)P(A) + P(B|A^c)P(A^c)$$

Where: A and A^c partition the sample space.

▸ *The workhorse behind Bayes and behind every default-probability tree. Make sure the partition is genuinely exhaustive.*

Sample variance (Bessel correction)

$$s^2 = [1/(n - 1)]\ \Sigma(X_i - \bar{X})^2$$

Where: n − 1 removes the downward bias.

▸ *Sample ⇒ n − 1. Population ⇒ N. GARP will hand you a population and offer the sample answer as a distractor.*

Pearson correlation coefficient

$$\rho_{X,Y} = \mathrm{Cov}(X,Y) / (\sigma_X \sigma_Y)$$

Where: Bounded in [−1, +1].

▸ *Linear association only. A perfect quadratic relationship shows ρ ≈ 0 — which is exactly why Part II reaches for copulas and rank correlations instead.*

Variance of a linear transformation

$$\mathrm{Var}(aX + b) = a^2\mathrm{Var}(X)$$

Where: a = scale, b = shift.

▸ *Adding a constant does nothing to variance. Scaling squares. Both facts are used constantly in VaR mapping.*

Variance of a two-asset weighted sum

$$\mathrm{Var}(aX + bY) = a^2\sigma^2_X + b^2\sigma^2_Y + 2ab\cdot\mathrm{Cov}(X,Y)$$

Where: a, b = weights.

▸ *The cross term is the diversification term. If Cov is negative, portfolio variance falls below the weighted average of the parts — the whole reason portfolios exist.*

Continuously compounded (log) return

$$r = \ln(P_t / P_{t-1}) = \ln(1 + R)$$

Where: R = the simple return over the period.

▸ *Log returns add across time; simple returns compound. FRM uses log returns almost everywhere, which is what makes square-root-of-time scaling legitimate.*

Expected value of a lognormal variable

$$E[X] = e^{(\mu + \sigma^2/2)}$$

Where: μ, σ² are the mean and variance of ln(X).

▸ *The σ²/2 is the convexity (Jensen) adjustment. Forgetting it is the classic lognormal error, and it recurs in Black-Scholes.*

Square-root-of-time volatility scaling

$$\sigma_T = \sigma_1 \times \sqrt{T}$$

Where: T = number of periods.

▸ *Valid ONLY under i.i.d. returns. Real returns are not: with POSITIVE autocorrelation (trending, momentum) square-root scaling UNDERSTATES long-horizon risk; with NEGATIVE autocorrelation (mean reversion) it OVERSTATES it. Know the direction depends on the sign — that is the conceptual question, not a blanket claim either way.*

OLS slope estimator (single regressor)

$$\hat{\beta}_1 = \mathrm{Cov}(X, Y) / \mathrm{Var}(X)$$

Where: Sample covariance over sample variance.

▸ *Note the denominator is the variance of the INDEPENDENT variable. This is also the definition of beta when Y is the asset and X is the market.*

Adjusted R-squared

$$\bar{R}^2 = 1 - (1 - R^2) \times [(n - 1)/(n - k - 1)]$$

Where: k = number of regressors.

▸ *Plain R^2 can never fall when you add a variable; adjusted R^2 can, and does whenever the new variable's $|t| < 1$. That is the signal the variable is not earning its place.*

One-sample t-statistic

$$t = (\bar{X} - \mu_0) / (s/\sqrt{n})$$

Where: Tests whether a mean differs from a hypothesised value.

▸ *Degrees of freedom $n - 1$. As n grows the t distribution converges to the normal — which is why large samples use z.*

Two-sample t-statistic

$$t = (\bar{X}_1 - \bar{X}_2) / \sqrt{(s^2_1/n_1 + s^2_2/n_2)}$$

Where: Difference of means, unequal variances.

▸ *The pooled-variance version assumes equal variances. Check which the question implies before you compute.*

F-statistic for a joint hypothesis

$$F = [(SSR\_R - SSR\_U)/q] / [SSR\_U/(n - k - 1)]$$

Where: SSR_R = restricted, SSR_U = unrestricted, q = number of restrictions.

▸ *Always a right-tailed test. F tests restrictions JOINTLY — variables can be individually insignificant yet jointly significant, which is the fingerprint of multicollinearity.*

Variance inflation factor

$$VIF_j = 1 / (1 - R^2_j)$$

Where: R^2_j from regressing regressor j on all the others.

▸ *VIF above 10 is the usual multicollinearity flag. Multicollinearity inflates standard errors — it does NOT bias the coefficients, and that distinction is examinable.*

Omitted variable bias

$$bias(\hat{\beta_1}) = \beta_2 \times \delta$$

Where: β_2 = the true coefficient on the omitted variable, δ = slope from regressing the omitted variable on the included one.

▸ *Bias requires BOTH: the omitted variable matters ($\beta_2 \neq 0$) AND it correlates with the included one ($\delta \neq 0$). Break either link and the bias disappears.*

Jarque-Bera test statistic

$$JB = (n/6)[S^2 + (K - 3)^2/4]$$

Where: S = skewness, K = kurtosis; chi-square with 2 d.o.f.

▸ *Tests normality by checking whether skew is 0 and kurtosis is 3. Financial returns fail it almost universally — which is the entire motivation for fat-tailed VaR.*

AR(1) mean-reverting level

$$\mu = \alpha / (1 - \phi)$$

Where: Requires $|\phi| < 1$ for stationarity.

▸ *If $\varphi \geq 1$ the series is non-stationary (a random walk) and the long-run mean does not exist. Check stationarity before you forecast anything.*

AR(1) h-step-ahead forecast

$$E[Y_{t+h}] = \mu + \phi^h(Y_t - \mu)$$

Where: h = forecast horizon.

▸ *As h grows, $\varphi^h \to 0$ and the forecast decays to the unconditional mean. A mean-reverting process forgets where it is — which is exactly what makes it forecastable in the short run and useless in the long run.*

Box-Pierce Q-statistic

$$Q\_BP = T \Sigma \rho^2\_k$$

Where: T = sample size, m = lags tested.

▸ *Tests whether residuals are jointly white noise. A significant Q means there is structure your model has not captured. Ljung-Box is the small-sample refinement of the same test.*

Ridge regression objective

$$\min \Sigma(y_i - \hat{y}_i)^2 + \lambda\, \Sigma\beta_j^2$$

Where: L2 penalty on the coefficients.

▸ *Ridge SHRINKS coefficients toward zero but never sets them exactly to zero. Good when regressors are collinear and you want to keep them all.*

LASSO regression objective

$$\min \Sigma(y_i - \hat{y}_i)^2 + \lambda\, \Sigma|\beta_j|$$

Where: L1 penalty on the coefficients.

▸ *LASSO drives some coefficients to EXACTLY zero, so it performs variable selection. Ridge shrinks; LASSO selects. That one-line contrast is the exam question.*

F1 score

$$F_1 = 2PR / (P + R)$$

Where: P = precision = TP/(TP+FP), R = recall = TP/(TP+FN).

▸ *The harmonic mean of precision and recall, so it punishes imbalance between them. For rare events like default, accuracy is meaningless — a model that predicts "no default" always is 99% accurate and completely useless.*

> **EXAM TIPS — QUANTITATIVE ANALYSIS**
>
> - The exam tests interpretation more than derivation. Given a regression output, you should be able to read off significance, model fit and violations in under a minute.
> - Know the three regression problems and their distinct consequences: heteroskedasticity and serial correlation corrupt the STANDARD ERRORS (coefficients stay unbiased); multicollinearity inflates them; omitted variables BIAS the coefficients themselves.
> - Square-root-of-time scaling assumes i.i.d. returns. When a question mentions volatility clustering or autocorrelation, it is telling you the assumption is broken.

FINANCIAL MARKETS & PRODUCTS · 26 formulas

Book 3. Derivatives, hedging, rates and FX. The largest formula block and the most calculation-heavy.

Forward price on a non-income asset

$$F_0 = S_0 \cdot e^{(rT)}$$

Where: Continuous compounding throughout.

▸ *The base case. Everything else in this section is this formula with something added to or subtracted from r.*

Forward price with a continuous income yield

$$F_0 = S_0 \cdot e^{((r - q)T)}$$

Where: q = dividend yield, or the foreign interest rate for FX.

▸ *Income lowers the forward price — you forgo the yield by holding the forward instead of the asset. Set q = r_foreign and you have covered interest parity in continuous form.*

Cost-of-carry forward price (commodity)

$$F_0 = S_0 \cdot e^{((r + u - y)T)}$$

Where: u = storage cost rate, y = convenience yield.

▸ *Storage pushes the forward UP; convenience yield pushes it DOWN. When y > r + u the market is in backwardation — a tight physical market. Get these two signs right and the topic is done.*

Long forward payoff

$$\text{Payoff} = S_T - K$$

Where: K = the delivery price locked in.

▸ *Linear and symmetric — unlimited on both sides. That is what separates a forward from an option, and it is why forwards need no premium.*

Put-call parity (European, no dividend)

$$c + K \cdot e^{(-rT)} = p + S_0$$

Where: Same strike, same expiry.

▸ *Note the continuous discounting — this is the FRM form. Rearrange it and every synthetic position falls out.*

European call lower bound

$$c \geq \max(S_0 - K \cdot e^{(-rT)}, 0)$$

Where: No dividends.

▸ *Enforced by arbitrage. It also proves you should never exercise an American call early on a non-dividend stock — the option is always worth more alive than exercised.*

European put lower bound

$$p \geq \max(K \cdot e^{(-rT)} - S_0, 0)$$

Where: No dividends.

▸ *Unlike the call, a deep in-the-money European PUT can trade below its intrinsic value, because you must wait for the strike. That asymmetry is why early exercise CAN be optimal for American puts.*

Long put payoff

$$\text{Payoff} = \max(K - S_T, 0)$$

Where: Payoff, not profit.

▸ *Subtract the premium for profit. GARP alternates between the two words deliberately — read which one is asked.*

Bull call spread maximum profit

$$\text{Max profit} = K_2 - K_1 - D$$

Where: Buy the K_1 call, sell the K_2 call; D = net debit.

▸ *Maximum loss is just D. Capping the upside is what makes it cheaper than an outright call.*

Long straddle breakevens

$$S^* = K \pm (c + p)$$

Where: Profit if $|S_T - K| > c + p$.

▸ *A pure volatility bet. You lose if nothing happens, and theta is grinding away the whole time you wait.*

Variance swap payoff

$$\text{Payoff} = N_{var} \times (\sigma^2_{realised} - K^2_{var})$$

Where: Settles on VARIANCE, not volatility.

▸ *Because it pays on the square, the payoff is convex in volatility — the long side gains more from a vol spike than it loses from an equal vol fall. That convexity is the whole product.*

Optimal number of futures contracts (untailed)

$$N^* = h^* \times (Q_A / Q_F)$$

Where: h* = minimum-variance hedge ratio, Q = quantities.

▸ *h* is just the regression slope of spot changes on futures changes. If it is not 1, you have basis risk — and basis risk is the point of the whole topic.*

Tailed number of futures contracts

$$N^*_{tailed} = h^* \times (V_A / V_F)$$

Where: V = dollar values rather than quantities.

▸ *Tailing adjusts for daily settlement: futures gains and losses are financed at the risk-free rate, so you need slightly fewer contracts. Tailing appears when the question mentions marking to market.*

Number of index futures to adjust beta

$$N^* = (\beta^* - \beta_0) \times P / F$$

Where: β^* = target beta, F = dollar value of one contract.

▸ *Set $\beta^* = 0$ to hedge out equity exposure entirely. Negative N^* means SELL futures — state the direction, not just the number.*

Duration-based futures hedge ratio

$$N^* = (P \times D_P) / (V_F \times D_F)$$

Where: D_F = duration of the cheapest-to-deliver bond.

▸ *This is dollar-duration matching. The CTD bond's duration, not the futures', is what drives the hedge — and identifying the CTD is a separate question in itself.*

Cheapest-to-deliver cost

$$\text{Cost} = \text{Quoted price} - (\text{Futures settlement} \times \text{Conversion factor})$$

Where: The short chooses which bond to deliver.

▸ *The short picks the bond that MINIMISES this cost. The conversion factor is meant to level the field between deliverable bonds and never quite does — which is the delivery option the short holds for free.*

Modified duration from Macaulay

$$D_{mod} = D_{Mac} / (1 + y/m)$$

Where: m = compounding periods per year.

▸ *Under CONTINUOUS compounding, modified duration equals Macaulay duration — the denominator disappears. GARP uses continuous compounding a lot, so watch which convention the question is in.*

Bond price change with duration and convexity

$$\Delta P/P \approx -D_{mod} \cdot \Delta y + \tfrac{1}{2} \cdot C \cdot (\Delta y)^2$$

Where: C = convexity.

▸ *The convexity term is positive, so duration alone always understates the price gain and overstates the loss. GARP signals it wants convexity by giving you a LARGE yield move.*

Covered interest rate parity

$$F = S \times (1 + r_d) / (1 + r_f)$$

Where: Domestic per foreign, rates matched to the horizon.

▸ *Enforced by arbitrage, so it holds. The higher-rate currency trades at a forward DISCOUNT — always.*

Uncovered interest rate parity

$$E[S_T] = S \times (1 + r_d) / (1 + r_f)$$

Where: An expectation, not an arbitrage relation.

▸ *It relies on expectations, so it does NOT hold empirically. The carry trade exists precisely because uncovered parity fails — the high-yield currency does not depreciate as much as it "should".*

Relative purchasing power parity

$$(S_1 - S_0)/S_0 \approx i_d - i_f$$

Where: i = inflation rates.

▸ *The higher-inflation currency depreciates. A long-run anchor and a poor short-run predictor, and GARP will make that distinction explicitly.*

Fisher relation

$$(1 + r) = (1 + \rho)(1 + i)$$

Where: r = nominal, ρ = real, i = expected inflation.

▸ *Exact form. The approximation $r \approx \rho + i$ only holds when the numbers are small — which they are not in an emerging-market question.*

Continuous-to-discrete compounding conversion

$$R_c = m \times \ln(1 + R_m/m)$$

Where: m = compounding frequency.

▸ *Master this conversion. Half the arithmetic errors in Book 3 are a rate quoted in one convention and used in another.*

FRA settlement payment

$$\text{Payment} = [N(r_{ref} - r_{FRA})(d/360)] / [1 + r_{ref}(d/360)]$$

Where: Settled at the START of the reference period.

▸ *The denominator discounts the payment back, because it settles up front rather than at the end of the period. Forgetting to discount is the standard FRA error.*

Swap value to the fixed receiver (two-bond method)

$$V = B_{fix} - B_{fl}$$

Where: B_{fix} = PV of a fixed-rate bond; B_{fl} = PV of a floating-rate bond.

▸ *On any reset date the floating leg is worth exactly par. That shortcut collapses most swap-valuation questions into a single line.*

Conditional prepayment rate from SMM

$$CPR = 1 - (1 - SMM)^{12}$$

Where: SMM = single monthly mortality.

▸ *Annualising a monthly rate compounds, it does not multiply by 12. The inverse — SMM from CPR — is what shows up in Part II securitisation.*

> **EXAM TIPS — FINANCIAL MARKETS & PRODUCTS**
>
> - Almost every pricing formula here is one exponential with an adjusted rate. Learn what goes INTO the exponent — r, minus income, plus storage, minus convenience — and you have learned the whole book.
> - Hedging questions want a direction as well as a number. Long the asset ⇒ SHORT futures. State it explicitly; the answer options will include the sign flip.
> - Basis risk is the theme of the hedging chapters. A perfect hedge is rare; the exam is really asking what residual exposure remains after you have hedged.

VALUATION & RISK MODELS · 23 formulas

Book 4. VaR, option pricing, credit risk models and Basel capital. The direct on-ramp to Part II.

Parametric (delta-normal) VaR

$$VaR_c = -\mu + z_c \cdot \sigma$$

Where: z_c = one-sided normal quantile (1.645 at 95%, 2.326 at 99%).

▸ *Fast, but it assumes normality — so it systematically UNDERSTATES tail risk for real financial returns, and it cannot handle option convexity at all.*

Expected shortfall (normal returns)

$$ES_c = \mu + \sigma \times \phi(z_c)/(1 - c)$$

Where: ϕ = standard normal density evaluated at z_c.

▸ *ES is the average loss GIVEN you breached VaR. It is sub-additive (VaR is not), so it is coherent — which is exactly why Basel moved from VaR to ES in the trading book.*

GARCH(1,1) variance recursion

$$\sigma^2_t = \omega + \alpha \cdot r^2_{t-1} + \beta \cdot \sigma^2_{t-1}$$

Where: ω = constant, α = weight on the last shock, β = weight on prior variance.

▸ *Persistence is $\alpha + \beta$; the long-run variance is $\omega/(1 - \alpha - \beta)$. If $\alpha + \beta \geq 1$ the process is not stationary. This explains volatility clustering in one line.*

Black-Scholes-Merton call price

$$C = S_0 \cdot N(d_1) - K \cdot e^{-rT} \cdot N(d_2)$$

Where: N = standard normal CDF.

▸ *$N(d_2)$ is the risk-neutral probability of finishing in the money. $N(d_1)$ is the delta. Knowing what each term MEANS is worth more than being able to reproduce them.*

d_1 in Black-Scholes-Merton

$$d_1 = [\ln(S_0/K) + (r + \sigma^2/2)T] / (\sigma\sqrt{T})$$

Where: $d_2 = d_1 - \sigma\sqrt{T}$.

▸ *The $+\sigma^2/2$ is the lognormal convexity adjustment — the same one from $E[X] = e^{(\mu+\sigma^2/2)}$. It is not decoration and it is not a typo.*

BSM gamma

$$\Gamma = \phi(d_1) / (S_0 \cdot \sigma \cdot \sqrt{T})$$

Where: ϕ = standard normal DENSITY (not the CDF).

▸ *Gamma peaks at the money and blows up close to expiry — which is where delta hedging becomes expensive and unstable. Long options are positive gamma.*

Option vega

$$\nu = \partial V / \partial \sigma$$

Where: Change in value per one-point change in volatility.

▸ *Positive for long calls AND long puts — buying any option is buying volatility. Largest at the money with a long time to maturity.*

Cox-Ross-Rubinstein up and down factors

$$u = e^{\sigma\sqrt{\Delta t}}$$
$$d = 1/u$$

Where: Δt = step length in years.

▸ *The $d = 1/u$ construction makes the tree recombine, which keeps the node count linear rather than exponential. That is the whole point of CRR.*

Risk-neutral probability in a binomial tree

$$p = (e^{r\Delta t} - d) / (u - d)$$

Where: The risk-neutral, NOT real-world, probability.

▸ *Nobody's forecast enters this. The investor's expected return is irrelevant to option pricing — that is the single most counterintuitive idea in derivatives, and GARP tests it as a concept.*

Effective duration from shocked prices

$$D_{eff} = (P_- - P_+) / (2 \times P_0 \times \Delta y)$$

Where: P_- = price after a yield drop, P_+ = after a rise.

▸ *Mandatory for bonds with embedded options, where the cash flows themselves change with rates.*

Macaulay duration

$$D_{Mac} = \Sigma\, t_i \times PV(C_i) / P$$

Where: PV-weighted average time to cash flow.

▸ *A zero-coupon bond has Macaulay duration exactly equal to its maturity. Anchor the concept on that.*

DV01

$$DV01 \approx D_{mod} \times P \times 10^{-4}$$

Where: Dollar price change for a 1 bp yield move.

▸ *The currency of all hedging in FRM. Hedge ratio = DV01 of the position ÷ DV01 of the hedge instrument.*

KR01 from key rate duration

$$KR01_k = KRD_k \times P \times 10^{-4}$$

Where: KRD_k = key rate duration at maturity point k.

▸ *The sum of the KR01s approximates the total DV01. KR01s are what let you hedge a NON-parallel shift — DV01 alone cannot.*

Forward rate between two dates (continuous)

$$f(t_1, t_2) = (s_2 t_2 - s_1 t_1) / (t_2 - t_1)$$

Where: s = spot rates.

▸ *Under continuous compounding this is a clean weighted difference — much friendlier than the discrete version. Yet another reason FRM prefers continuous rates.*

Bond price from discount factors

$$P = \Sigma\ c \cdot d(t_i) + \text{Principal} \cdot d(t_n)$$

Where: d(t) = discount factor for time t.

▸ *Model-free: no yield, no assumptions. Discount factors come straight from observed prices, which is why this is the bootstrapping starting point.*

Effective annual rate

$$EAR = (1 + r/n)^n - 1$$

Where: n = compounding periods per year.

▸ *The only honest way to compare rates quoted on different compounding conventions. Always convert before comparing.*

Loss given default

$$LGD = 1 - RR$$

Where: RR = recovery rate.

▸ *Trivial arithmetic, but recovery is empirically CORRELATED with default — recoveries fall exactly when defaults spike. Models that treat LGD as a constant understate tail loss badly.*

Unexpected loss (single exposure)

$$UL = EAD \times LGD \times \sqrt{PD(1 - PD)}$$

Where: The standard deviation of loss under a binomial default.

▸ *UL peaks at PD = 0.5 and shrinks as PD approaches 0 or 1 — near-certain outcomes are not uncertain. Capital is held against UL, not EL.*

Survival probability (constant hazard)

$$P(\tau > t) = e^{-\lambda t}$$

Where: λ = constant hazard rate (default intensity).

▸ *The exponential model. Memoryless: having survived five years tells you nothing about the sixth.*

Cumulative default probability (constant hazard)

$$P(\tau \le t) = 1 - e^{-\lambda t}$$

Where: One minus the survival probability.

▸ *Cumulative default probability rises with horizon and asymptotes at 1. Do not confuse it with the CONDITIONAL (marginal) probability below.*

Conditional one-year default probability

$$P(\text{default next year} \mid \text{survived}) = 1 - e^{-\lambda}$$

Where: Constant intensity ⇒ the same number every year.

▸ *This is the trio GARP loves to jumble: unconditional cumulative, conditional (given survival), and the hazard rate itself. Label which one the question wants before you compute.*

Vasicek single-factor credit VaR (Basel IRB)

$$VaR\_c = \Phi\left[\left(\Phi^{-1}(PD) + \sqrt{\rho} \cdot \Phi^{-1}(c)\right) / \sqrt{1 - \rho} \right]$$

Where: ρ = asset correlation, c = confidence level (99.9% under Basel).

▸ *The formula sitting underneath the entire IRB capital framework. Higher asset correlation ⇒ more systematic risk ⇒ dramatically more capital. Note it gives the CONDITIONAL default rate in a bad state, from which capital is derived.*

Basel market-risk capital with stressed VaR

$$K = \max(VaR, m_c \times VaR_{60}d\text{-}avg) + \max(sVaR, m_s \times sVaR_{60}d\text{-}avg)$$

Where: m = supervisory multipliers, typically 3+.

▸ *Stressed VaR was Basel 2.5's answer to 2008: VaR calibrated on calm data collapsed exactly when it was needed. The multiplier and the 60-day average both exist to stop banks gaming a quiet window.*

EXAM TIPS — VALUATION & RISK MODELS

- VaR is the spine of Book 4 and of Part II. Know all three approaches and where each breaks: parametric (fails on fat tails and options), historical (assumes the past repeats, and one bad day can dominate), Monte Carlo (flexible but model-dependent and slow).
- VaR is NOT sub-additive: the VaR of a combined portfolio can exceed the sum of the parts. That single failure is why expected shortfall replaced it in the Basel trading book. Be ready to say it in one sentence.
- Get comfortable with the hazard-rate family — survival, cumulative default, conditional default. Three formulas, one exponential, and endless opportunity to answer the wrong one.

PASSING FRM PART I

Know cold, no thinking required

- EL = PD × LGD × EAD, and why capital is held against UL instead.
- The full VaR family: parametric, historical, Monte Carlo, and expected shortfall.
- Forward pricing under cost-of-carry, with every sign in the exponent.
- Hedge ratios: minimum-variance, duration-based, and beta-adjusted — including the direction.
- The hazard-rate trio: survival, cumulative default, conditional default.
- Black-Scholes inputs and what $N(d_1)$ and $N(d_2)$ each actually mean.

The traps that cost people the exam

- Continuous versus discrete compounding. GARP mixes conventions deliberately.
- Payoff versus profit on options. The premium is the whole difference.
- Sample (n − 1) versus population (N) variance.
- VaR at 95% uses z = 1.645; at 99% it is 2.326. Memorise both.
- Sign of the futures position. Long the asset ⇒ short the hedge.
- Annualising a monthly rate compounds — it does not multiply by 12.

How to revise from here

- Part I is a breadth exam and it is graded on a curve. Broad competence beats deep mastery of two books.
- Roughly 2.4 minutes per question. Practise at that pace with an approved calculator (BA II Plus or HP 12C) — nothing else is allowed in the room.
- Quantitative Analysis is the foundation for all of Part II. Time spent there pays twice.
- Track errors by TYPE, not by topic. "Misread the question" and "did not know the formula" need entirely different fixes.