1. IVP (theoreticals)
   (a) Some sample IVPs, e.g. $y' = \lambda y$, Hamiltonian systems, $y' = \frac{y}{1-y^2}, y(0) = 0$
   (b) Lipschitz Condition (analyze some examples)
   (c) Well-posedness and its importance
   (d) Theorem: Continuity + Lipschitz condition $\Rightarrow$ well-posedness
2. Euler's Method
   (a) Sample problem $y' = \lambda y$
   (b) Graphical interpretations
   (c) Local truncation error
   (d) $y(t_{n+1}) = y(t_n) + \int_{t_n}^{t_{n+1}} f(s, y(s))ds$. General methods can be derived by approximating the integral
3. Taylor's Method
   (a) Sample problem $y' = ye^t, y(0) = 1$
   (b) Taylor expansion with 2 variables
   (c) Big O notations
4. RK
   (a) Midpoint Method (& it's local truncation error)
   (b) Consistency formula (& higher order formula)
   (c) $y(t_{n+1}) = y(t_n) + \int_{t_n}^{t_{n+1}} f(s, y(s))ds$; quadrature rules help approximate the integral
   (d) Butcher tableau
   (e) Stability = continuity + Lipschitz condition
5. Multistep Methods
   (a) Proper formulation of multiple Taylor expansions
   (b) Consistency formula (& higher order formula)
   (c) Newton backward-difference formula

$$\begin{aligned}\int_{t_i}^{t_{i+1}} P_m(t)dt &= \int_{t_i}^{t_{i+1}} \sum_{k=0}^{m} (-1)^k \binom{-s+1}{k} \nabla^k f(t_{i+1}, y(t_{i+1}))dt \\ &= h \sum_{k=0}^{m} \nabla^k f(t_{i+1}, y(t_{i+1}))(-1)^k \int_0^1 \binom{-s+1}{k} ds\end{aligned}$$

k	0	1	2	3	4	5	$\cdots$
$(-1)^k \int_0^1 \binom{-s+1}{k} ds$	1	$-\frac{1}{2}$	$-\frac{1}{12}$	$-\frac{1}{24}$	$-\frac{19}{720}$	$-\frac{3}{160}$	$\cdots$

   (d) Stability = root condition (+ continuity + Lipschitz condition)
   (e) Lax equivalence

6. Stiff Equations, BVPs
   (a) Region of absolute stability
   (b) A-stability
   (c) E & U for solutions to BVPs
   (d) Shooting method (linear & nonlinear)
   (e) Finite difference method

7. Nonlinear System Solvers
   (a) Fix-point method
   (b) Newton's method
   (c) (Broydent's method)
   (d) Steepest descent method
   (e) Homotopy method
   (f) (find textbook problems, derive derivatives, and explain the concepts)

8. Eigen Problems (Power Method, QR-Algorithm)
   (a) Diagonalizablility conditions
   (b) Norms are all equivalent
   (c) Shifted inverse power method
   (d) Householder transformation and its graphical interpretations and examples
   (e) Why does Gram-Schmidt suck? $v_1 = (1, \epsilon, 0, 0), v_2 = (1, 0, \epsilon, 0), v_3 = (1, 0, 0, \epsilon)$

9. Fast Fourier Transform
   (a) ???