```
=== CIFAR-10 Classification: Optimizer and Scheduler Comparison ===
Using device: cuda
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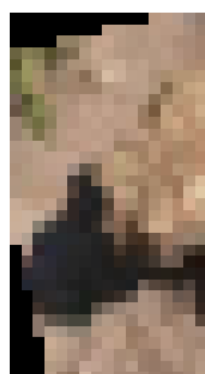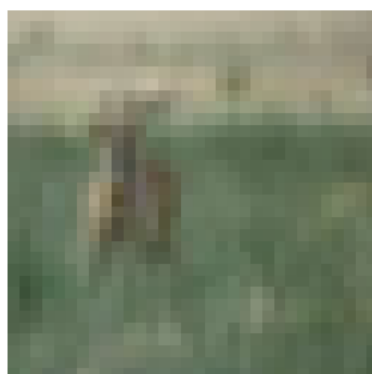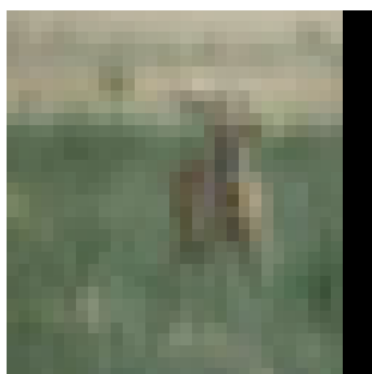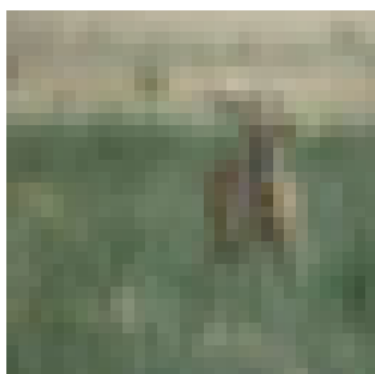| Original | Random Crop | Horizontal Flip | Rotat |

```
=== Running Experiment: SGD_NoScheduler ===
Model parameters: 1,149,770
Using SGD optimizer with learning rate: 0.01
No learning rate scheduler
[Epoch: 1/50] Loss: 1.5609, Accuracy: 42.46%, Learning rate: 0.010000,
Time: 24.15s
[Epoch: 2/50] Loss: 1.1763, Accuracy: 58.06%, Learning rate: 0.010000,
Time: 23.82s
[Epoch: 3/50] Loss: 1.0097, Accuracy: 64.23%, Learning rate: 0.010000,
Time: 24.00s
[Epoch: 4/50] Loss: 0.9044, Accuracy: 68.18%, Learning rate: 0.010000,
Time: 23.73s
[Epoch: 5/50] Loss: 0.8305, Accuracy: 71.01%, Learning rate: 0.010000,
Time: 24.32s
[Epoch: 6/50] Loss: 0.7727, Accuracy: 73.17%, Learning rate: 0.010000,
Time: 23.89s
[Epoch: 7/50] Loss: 0.7275, Accuracy: 74.88%, Learning rate: 0.010000,
Time: 23.74s
[Epoch: 8/50] Loss: 0.6923, Accuracy: 76.09%, Learning rate: 0.010000,
Time: 24.69s
[Epoch: 9/50] Loss: 0.6587, Accuracy: 77.17%, Learning rate: 0.010000,
Time: 24.03s
[Epoch: 10/50] Loss: 0.6287, Accuracy: 78.46%, Learning rate: 0.010000,
Time: 24.23s
[Epoch: 11/50] Loss: 0.6094, Accuracy: 78.92%, Learning rate: 0.010000,
Time: 24.12s
[Epoch: 12/50] Loss: 0.5829, Accuracy: 79.89%, Learning rate: 0.010000,
Time: 23.71s
[Epoch: 13/50] Loss: 0.5676, Accuracy: 80.25%, Learning rate: 0.010000,
Time: 23.82s
[Epoch: 14/50] Loss: 0.5523, Accuracy: 81.06%, Learning rate: 0.010000,
Time: 23.98s
[Epoch: 15/50] Loss: 0.5323, Accuracy: 81.68%, Learning rate: 0.010000,
Time: 23.74s
[Epoch: 16/50] Loss: 0.5192, Accuracy: 82.07%, Learning rate: 0.010000,
Time: 23.87s
[Epoch: 17/50] Loss: 0.4962, Accuracy: 82.85%, Learning rate: 0.010000,
Time: 23.75s
[Epoch: 18/50] Loss: 0.4852, Accuracy: 83.22%, Learning rate: 0.010000,
Time: 24.03s
[Epoch: 19/50] Loss: 0.4727, Accuracy: 83.61%, Learning rate: 0.010000,
Time: 23.75s
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[Epoch: 20/50] Loss: 0.4664, Accuracy: 83.97%, Learning rate: 0.010000, Time: 23.78s
[Epoch: 21/50] Loss: 0.4542, Accuracy: 84.42%, Learning rate: 0.010000, Time: 23.66s
[Epoch: 22/50] Loss: 0.4457, Accuracy: 84.43%, Learning rate: 0.010000, Time: 23.75s
[Epoch: 23/50] Loss: 0.4328, Accuracy: 85.05%, Learning rate: 0.010000, Time: 24.04s
[Epoch: 24/50] Loss: 0.4296, Accuracy: 85.30%, Learning rate: 0.010000, Time: 23.86s
[Epoch: 25/50] Loss: 0.4173, Accuracy: 85.52%, Learning rate: 0.010000, Time: 23.82s
[Epoch: 26/50] Loss: 0.4098, Accuracy: 85.69%, Learning rate: 0.010000, Time: 23.84s
[Epoch: 27/50] Loss: 0.4036, Accuracy: 86.19%, Learning rate: 0.010000, Time: 24.17s
[Epoch: 28/50] Loss: 0.3982, Accuracy: 86.25%, Learning rate: 0.010000, Time: 23.90s
[Epoch: 29/50] Loss: 0.3848, Accuracy: 86.82%, Learning rate: 0.010000, Time: 23.78s
[Epoch: 30/50] Loss: 0.3823, Accuracy: 86.83%, Learning rate: 0.010000, Time: 23.95s
[Epoch: 31/50] Loss: 0.3728, Accuracy: 87.20%, Learning rate: 0.010000, Time: 23.79s
[Epoch: 32/50] Loss: 0.3681, Accuracy: 87.32%, Learning rate: 0.010000, Time: 24.38s
[Epoch: 33/50] Loss: 0.3638, Accuracy: 87.39%, Learning rate: 0.010000, Time: 23.93s
[Epoch: 34/50] Loss: 0.3589, Accuracy: 87.54%, Learning rate: 0.010000, Time: 24.31s
[Epoch: 35/50] Loss: 0.3503, Accuracy: 87.96%, Learning rate: 0.010000, Time: 24.31s
[Epoch: 36/50] Loss: 0.3476, Accuracy: 88.03%, Learning rate: 0.010000, Time: 24.21s
[Epoch: 37/50] Loss: 0.3422, Accuracy: 88.19%, Learning rate: 0.010000, Time: 23.75s
[Epoch: 38/50] Loss: 0.3400, Accuracy: 88.23%, Learning rate: 0.010000, Time: 23.66s
[Epoch: 39/50] Loss: 0.3375, Accuracy: 88.31%, Learning rate: 0.010000, Time: 24.08s
[Epoch: 40/50] Loss: 0.3291, Accuracy: 88.62%, Learning rate: 0.010000, Time: 23.75s

[Epoch: 41/50] Loss: 0.3237, Accuracy: 88.94%, Learning rate: 0.010000,
Time: 23.81s
[Epoch: 42/50] Loss: 0.3243, Accuracy: 88.82%, Learning rate: 0.010000,
Time: 23.93s
[Epoch: 43/50] Loss: 0.3234, Accuracy: 88.72%, Learning rate: 0.010000,
Time: 24.04s
[Epoch: 44/50] Loss: 0.3194, Accuracy: 88.81%, Learning rate: 0.010000,
Time: 23.76s
[Epoch: 45/50] Loss: 0.3125, Accuracy: 89.20%, Learning rate: 0.010000,
Time: 23.80s
[Epoch: 46/50] Loss: 0.3062, Accuracy: 89.51%, Learning rate: 0.010000,
Time: 23.77s
[Epoch: 47/50] Loss: 0.3090, Accuracy: 89.38%, Learning rate: 0.010000,
Time: 23.92s
[Epoch: 48/50] Loss: 0.3125, Accuracy: 89.14%, Learning rate: 0.010000,
Time: 24.01s
[Epoch: 49/50] Loss: 0.2990, Accuracy: 89.50%, Learning rate: 0.010000,
Time: 23.75s
[Epoch: 50/50] Loss: 0.2998, Accuracy: 89.61%, Learning rate: 0.010000,
Time: 23.80s
Test set accuracy: 86.92%

=== Running Experiment: SGD_StepLR ===
Model parameters: 1,149,770
Using SGD optimizer with learning rate: 0.01
Using StepLR scheduler with step_size=15, gamma=0.1
[Epoch: 1/50] Loss: 1.5582, Accuracy: 42.62%, Learning rate: 0.010000,
Time: 24.06s
[Epoch: 2/50] Loss: 1.1810, Accuracy: 57.44%, Learning rate: 0.010000,
Time: 24.11s
[Epoch: 3/50] Loss: 1.0199, Accuracy: 63.83%, Learning rate: 0.010000,
Time: 23.95s
[Epoch: 4/50] Loss: 0.9114, Accuracy: 67.87%, Learning rate: 0.010000,
Time: 24.02s
[Epoch: 5/50] Loss: 0.8354, Accuracy: 71.05%, Learning rate: 0.010000,
Time: 24.36s
[Epoch: 6/50] Loss: 0.7748, Accuracy: 73.14%, Learning rate: 0.010000,
Time: 23.91s
[Epoch: 7/50] Loss: 0.7291, Accuracy: 74.51%, Learning rate: 0.010000,
Time: 24.03s
[Epoch: 8/50] Loss: 0.6879, Accuracy: 76.06%, Learning rate: 0.010000,
Time: 23.93s

[Epoch: 9/50] Loss: 0.6584, Accuracy: 77.39%, Learning rate: 0.010000, Time: 24.08s
[Epoch: 10/50] Loss: 0.6339, Accuracy: 78.18%, Learning rate: 0.010000, Time: 24.23s
[Epoch: 11/50] Loss: 0.6031, Accuracy: 79.27%, Learning rate: 0.010000, Time: 24.03s
[Epoch: 12/50] Loss: 0.5797, Accuracy: 79.78%, Learning rate: 0.010000, Time: 23.97s
[Epoch: 13/50] Loss: 0.5604, Accuracy: 80.52%, Learning rate: 0.010000, Time: 23.89s
[Epoch: 14/50] Loss: 0.5470, Accuracy: 81.14%, Learning rate: 0.010000, Time: 23.92s
[Epoch: 15/50] Loss: 0.5284, Accuracy: 81.69%, Learning rate: 0.001000, Time: 23.84s
[Epoch: 16/50] Loss: 0.4419, Accuracy: 85.03%, Learning rate: 0.001000, Time: 23.73s
[Epoch: 17/50] Loss: 0.4243, Accuracy: 85.55%, Learning rate: 0.001000, Time: 24.52s
[Epoch: 18/50] Loss: 0.4108, Accuracy: 85.81%, Learning rate: 0.001000, Time: 24.11s
[Epoch: 19/50] Loss: 0.4055, Accuracy: 86.07%, Learning rate: 0.001000, Time: 24.31s
[Epoch: 20/50] Loss: 0.3990, Accuracy: 86.38%, Learning rate: 0.001000, Time: 24.48s
[Epoch: 21/50] Loss: 0.3915, Accuracy: 86.66%, Learning rate: 0.001000, Time: 24.23s
[Epoch: 22/50] Loss: 0.3894, Accuracy: 86.75%, Learning rate: 0.001000, Time: 24.06s
[Epoch: 23/50] Loss: 0.3869, Accuracy: 86.66%, Learning rate: 0.001000, Time: 24.12s
[Epoch: 24/50] Loss: 0.3813, Accuracy: 86.89%, Learning rate: 0.001000, Time: 23.86s
[Epoch: 25/50] Loss: 0.3813, Accuracy: 87.00%, Learning rate: 0.001000, Time: 23.72s
[Epoch: 26/50] Loss: 0.3760, Accuracy: 87.08%, Learning rate: 0.001000, Time: 23.93s
[Epoch: 27/50] Loss: 0.3766, Accuracy: 87.07%, Learning rate: 0.001000, Time: 23.97s
[Epoch: 28/50] Loss: 0.3689, Accuracy: 87.44%, Learning rate: 0.001000, Time: 23.83s
[Epoch: 29/50] Loss: 0.3694, Accuracy: 87.37%, Learning rate: 0.001000, Time: 24.36s

[Epoch: 30/50] Loss: 0.3665, Accuracy: 87.30%, Learning rate: 0.000100, Time: 24.05s
[Epoch: 31/50] Loss: 0.3519, Accuracy: 87.96%, Learning rate: 0.000100, Time: 23.90s
[Epoch: 32/50] Loss: 0.3494, Accuracy: 87.95%, Learning rate: 0.000100, Time: 24.27s
[Epoch: 33/50] Loss: 0.3487, Accuracy: 88.10%, Learning rate: 0.000100, Time: 24.49s
[Epoch: 34/50] Loss: 0.3487, Accuracy: 88.17%, Learning rate: 0.000100, Time: 24.47s
[Epoch: 35/50] Loss: 0.3455, Accuracy: 88.17%, Learning rate: 0.000100, Time: 24.11s
[Epoch: 36/50] Loss: 0.3433, Accuracy: 88.22%, Learning rate: 0.000100, Time: 23.60s
[Epoch: 37/50] Loss: 0.3448, Accuracy: 88.26%, Learning rate: 0.000100, Time: 24.17s
[Epoch: 38/50] Loss: 0.3437, Accuracy: 88.14%, Learning rate: 0.000100, Time: 23.85s
[Epoch: 39/50] Loss: 0.3444, Accuracy: 88.20%, Learning rate: 0.000100, Time: 23.76s
[Epoch: 40/50] Loss: 0.3432, Accuracy: 88.16%, Learning rate: 0.000100, Time: 24.11s
[Epoch: 41/50] Loss: 0.3422, Accuracy: 88.24%, Learning rate: 0.000100, Time: 23.81s
[Epoch: 42/50] Loss: 0.3398, Accuracy: 88.21%, Learning rate: 0.000100, Time: 23.83s
[Epoch: 43/50] Loss: 0.3442, Accuracy: 88.21%, Learning rate: 0.000100, Time: 23.70s
[Epoch: 44/50] Loss: 0.3420, Accuracy: 88.31%, Learning rate: 0.000100, Time: 23.77s
[Epoch: 45/50] Loss: 0.3410, Accuracy: 88.24%, Learning rate: 0.000010, Time: 24.26s
[Epoch: 46/50] Loss: 0.3365, Accuracy: 88.40%, Learning rate: 0.000010, Time: 23.96s
[Epoch: 47/50] Loss: 0.3431, Accuracy: 88.34%, Learning rate: 0.000010, Time: 24.00s
[Epoch: 48/50] Loss: 0.3349, Accuracy: 88.56%, Learning rate: 0.000010, Time: 23.97s
[Epoch: 49/50] Loss: 0.3379, Accuracy: 88.34%, Learning rate: 0.000010, Time: 23.81s
[Epoch: 50/50] Loss: 0.3409, Accuracy: 88.37%, Learning rate: 0.000010, Time: 24.08s
Test set accuracy: 88.57%

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=== Running Experiment: SGD_CosineAnnealing ===
Model parameters: 1,149,770
Using SGD optimizer with learning rate: 0.01
Using CosineAnnealingLR scheduler with T_max=50
[Epoch: 1/50] Loss: 1.5585, Accuracy: 42.59%, Learning rate: 0.009990,
Time: 24.47s
[Epoch: 2/50] Loss: 1.1820, Accuracy: 57.49%, Learning rate: 0.009961,
Time: 24.09s
[Epoch: 3/50] Loss: 1.0252, Accuracy: 63.70%, Learning rate: 0.009911,
Time: 23.79s
[Epoch: 4/50] Loss: 0.9264, Accuracy: 67.31%, Learning rate: 0.009843,
Time: 23.78s
[Epoch: 5/50] Loss: 0.8398, Accuracy: 70.61%, Learning rate: 0.009755,
Time: 24.33s
[Epoch: 6/50] Loss: 0.7797, Accuracy: 72.84%, Learning rate: 0.009649,
Time: 24.16s
[Epoch: 7/50] Loss: 0.7331, Accuracy: 74.39%, Learning rate: 0.009524,
Time: 24.20s
[Epoch: 8/50] Loss: 0.6903, Accuracy: 76.18%, Learning rate: 0.009382,
Time: 23.91s
[Epoch: 9/50] Loss: 0.6656, Accuracy: 77.05%, Learning rate: 0.009222,
Time: 24.15s
[Epoch: 10/50] Loss: 0.6367, Accuracy: 77.70%, Learning rate: 0.009045,
Time: 23.83s
[Epoch: 11/50] Loss: 0.6058, Accuracy: 79.10%, Learning rate: 0.008853,
Time: 23.93s
[Epoch: 12/50] Loss: 0.5797, Accuracy: 80.11%, Learning rate: 0.008645,
Time: 23.72s
[Epoch: 13/50] Loss: 0.5648, Accuracy: 80.47%, Learning rate: 0.008423,
Time: 23.86s
[Epoch: 14/50] Loss: 0.5400, Accuracy: 81.37%, Learning rate: 0.008187,
Time: 23.85s
[Epoch: 15/50] Loss: 0.5202, Accuracy: 81.95%, Learning rate: 0.007939,
Time: 24.44s
[Epoch: 16/50] Loss: 0.5066, Accuracy: 82.55%, Learning rate: 0.007679,
Time: 23.77s
[Epoch: 17/50] Loss: 0.4939, Accuracy: 82.90%, Learning rate: 0.007409,
Time: 23.88s
[Epoch: 18/50] Loss: 0.4786, Accuracy: 83.61%, Learning rate: 0.007129,
Time: 23.85s
[Epoch: 19/50] Loss: 0.4650, Accuracy: 83.90%, Learning rate: 0.006841,
Time: 23.78s
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[Epoch: 20/50] Loss: 0.4484, Accuracy: 84.45%, Learning rate: 0.006545, Time: 23.76s
[Epoch: 21/50] Loss: 0.4319, Accuracy: 85.14%, Learning rate: 0.006243, Time: 23.71s
[Epoch: 22/50] Loss: 0.4240, Accuracy: 85.35%, Learning rate: 0.005937, Time: 24.05s
[Epoch: 23/50] Loss: 0.4138, Accuracy: 85.86%, Learning rate: 0.005627, Time: 23.91s
[Epoch: 24/50] Loss: 0.3974, Accuracy: 86.29%, Learning rate: 0.005314, Time: 24.01s
[Epoch: 25/50] Loss: 0.3913, Accuracy: 86.49%, Learning rate: 0.005000, Time: 23.75s
[Epoch: 26/50] Loss: 0.3770, Accuracy: 86.93%, Learning rate: 0.004686, Time: 24.09s
[Epoch: 27/50] Loss: 0.3705, Accuracy: 87.11%, Learning rate: 0.004373, Time: 24.05s
[Epoch: 28/50] Loss: 0.3611, Accuracy: 87.54%, Learning rate: 0.004063, Time: 23.86s
[Epoch: 29/50] Loss: 0.3466, Accuracy: 88.02%, Learning rate: 0.003757, Time: 23.92s
[Epoch: 30/50] Loss: 0.3416, Accuracy: 88.25%, Learning rate: 0.003455, Time: 23.86s
[Epoch: 31/50] Loss: 0.3297, Accuracy: 88.50%, Learning rate: 0.003159, Time: 24.47s
[Epoch: 32/50] Loss: 0.3201, Accuracy: 88.88%, Learning rate: 0.002871, Time: 23.88s
[Epoch: 33/50] Loss: 0.3111, Accuracy: 89.45%, Learning rate: 0.002591, Time: 23.78s
[Epoch: 34/50] Loss: 0.3036, Accuracy: 89.60%, Learning rate: 0.002321, Time: 24.61s
[Epoch: 35/50] Loss: 0.2951, Accuracy: 89.79%, Learning rate: 0.002061, Time: 23.81s
[Epoch: 36/50] Loss: 0.2875, Accuracy: 90.26%, Learning rate: 0.001813, Time: 23.77s
[Epoch: 37/50] Loss: 0.2770, Accuracy: 90.65%, Learning rate: 0.001577, Time: 23.90s
[Epoch: 38/50] Loss: 0.2717, Accuracy: 90.63%, Learning rate: 0.001355, Time: 23.90s
[Epoch: 39/50] Loss: 0.2662, Accuracy: 90.81%, Learning rate: 0.001147, Time: 24.19s
[Epoch: 40/50] Loss: 0.2569, Accuracy: 91.20%, Learning rate: 0.000955, Time: 23.73s

[Epoch: 41/50] Loss: 0.2526, Accuracy: 91.31%, Learning rate: 0.000778, Time: 24.05s
[Epoch: 42/50] Loss: 0.2487, Accuracy: 91.45%, Learning rate: 0.000618, Time: 23.74s
[Epoch: 43/50] Loss: 0.2436, Accuracy: 91.61%, Learning rate: 0.000476, Time: 24.22s
[Epoch: 44/50] Loss: 0.2355, Accuracy: 91.98%, Learning rate: 0.000351, Time: 24.14s
[Epoch: 45/50] Loss: 0.2345, Accuracy: 92.03%, Learning rate: 0.000245, Time: 23.84s
[Epoch: 46/50] Loss: 0.2313, Accuracy: 92.07%, Learning rate: 0.000157, Time: 23.72s
[Epoch: 47/50] Loss: 0.2294, Accuracy: 92.15%, Learning rate: 0.000089, Time: 23.89s
[Epoch: 48/50] Loss: 0.2257, Accuracy: 92.39%, Learning rate: 0.000039, Time: 23.76s
[Epoch: 49/50] Loss: 0.2263, Accuracy: 92.22%, Learning rate: 0.000010, Time: 23.74s
[Epoch: 50/50] Loss: 0.2236, Accuracy: 92.32%, Learning rate: 0.000000, Time: 24.34s
Test set accuracy: 90.33%

=== Running Experiment: Adam_NoScheduler ===
Model parameters: 1,149,770
Using Adam optimizer with learning rate: 0.001
No learning rate scheduler
[Epoch: 1/50] Loss: 1.4612, Accuracy: 46.53%, Learning rate: 0.001000, Time: 23.74s
[Epoch: 2/50] Loss: 1.1000, Accuracy: 61.16%, Learning rate: 0.001000, Time: 24.09s
[Epoch: 3/50] Loss: 0.9401, Accuracy: 67.00%, Learning rate: 0.001000, Time: 24.07s
[Epoch: 4/50] Loss: 0.8352, Accuracy: 70.97%, Learning rate: 0.001000, Time: 24.09s
[Epoch: 5/50] Loss: 0.7672, Accuracy: 73.27%, Learning rate: 0.001000, Time: 24.27s
[Epoch: 6/50] Loss: 0.7132, Accuracy: 75.45%, Learning rate: 0.001000, Time: 24.30s
[Epoch: 7/50] Loss: 0.6755, Accuracy: 76.55%, Learning rate: 0.001000, Time: 24.10s
[Epoch: 8/50] Loss: 0.6403, Accuracy: 78.02%, Learning rate: 0.001000, Time: 23.77s

[Epoch: 9/50] Loss: 0.6119, Accuracy: 79.04%, Learning rate: 0.001000, Time: 23.89s
[Epoch: 10/50] Loss: 0.5938, Accuracy: 79.66%, Learning rate: 0.001000, Time: 23.84s
[Epoch: 11/50] Loss: 0.5674, Accuracy: 80.50%, Learning rate: 0.001000, Time: 24.18s
[Epoch: 12/50] Loss: 0.5501, Accuracy: 81.10%, Learning rate: 0.001000, Time: 23.86s
[Epoch: 13/50] Loss: 0.5413, Accuracy: 81.51%, Learning rate: 0.001000, Time: 23.61s
[Epoch: 14/50] Loss: 0.5245, Accuracy: 82.02%, Learning rate: 0.001000, Time: 23.98s
[Epoch: 15/50] Loss: 0.5094, Accuracy: 82.76%, Learning rate: 0.001000, Time: 24.26s
[Epoch: 16/50] Loss: 0.4979, Accuracy: 83.03%, Learning rate: 0.001000, Time: 23.88s
[Epoch: 17/50] Loss: 0.4898, Accuracy: 83.41%, Learning rate: 0.001000, Time: 23.80s
[Epoch: 18/50] Loss: 0.4836, Accuracy: 83.44%, Learning rate: 0.001000, Time: 24.53s
[Epoch: 19/50] Loss: 0.4749, Accuracy: 83.82%, Learning rate: 0.001000, Time: 24.21s
[Epoch: 20/50] Loss: 0.4658, Accuracy: 84.04%, Learning rate: 0.001000, Time: 24.00s
[Epoch: 21/50] Loss: 0.4651, Accuracy: 84.26%, Learning rate: 0.001000, Time: 23.96s
[Epoch: 22/50] Loss: 0.4558, Accuracy: 84.55%, Learning rate: 0.001000, Time: 23.94s
[Epoch: 23/50] Loss: 0.4476, Accuracy: 84.82%, Learning rate: 0.001000, Time: 23.78s
[Epoch: 24/50] Loss: 0.4449, Accuracy: 84.65%, Learning rate: 0.001000, Time: 24.15s
[Epoch: 25/50] Loss: 0.4379, Accuracy: 85.05%, Learning rate: 0.001000, Time: 23.80s
[Epoch: 26/50] Loss: 0.4386, Accuracy: 85.16%, Learning rate: 0.001000, Time: 23.82s
[Epoch: 27/50] Loss: 0.4328, Accuracy: 85.21%, Learning rate: 0.001000, Time: 24.20s
[Epoch: 28/50] Loss: 0.4234, Accuracy: 85.55%, Learning rate: 0.001000, Time: 23.89s
[Epoch: 29/50] Loss: 0.4282, Accuracy: 85.31%, Learning rate: 0.001000, Time: 24.41s

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[Epoch: 30/50] Loss: 0.4199, Accuracy: 85.70%, Learning rate: 0.001000,
Time: 24.08s
[Epoch: 31/50] Loss: 0.4141, Accuracy: 85.96%, Learning rate: 0.001000,
Time: 23.82s
[Epoch: 32/50] Loss: 0.4144, Accuracy: 85.83%, Learning rate: 0.001000,
Time: 23.74s
[Epoch: 33/50] Loss: 0.4145, Accuracy: 85.82%, Learning rate: 0.001000,
Time: 23.72s
[Epoch: 34/50] Loss: 0.4078, Accuracy: 86.19%, Learning rate: 0.001000,
Time: 24.00s
[Epoch: 35/50] Loss: 0.4074, Accuracy: 86.11%, Learning rate: 0.001000,
Time: 23.85s
[Epoch: 36/50] Loss: 0.4055, Accuracy: 86.24%, Learning rate: 0.001000,
Time: 24.47s
[Epoch: 37/50] Loss: 0.4012, Accuracy: 86.19%, Learning rate: 0.001000,
Time: 23.97s
[Epoch: 38/50] Loss: 0.3995, Accuracy: 86.38%, Learning rate: 0.001000,
Time: 24.10s
[Epoch: 39/50] Loss: 0.3961, Accuracy: 86.48%, Learning rate: 0.001000,
Time: 23.83s
[Epoch: 40/50] Loss: 0.3963, Accuracy: 86.73%, Learning rate: 0.001000,
Time: 23.93s
[Epoch: 41/50] Loss: 0.3921, Accuracy: 86.61%, Learning rate: 0.001000,
Time: 23.69s
[Epoch: 42/50] Loss: 0.3914, Accuracy: 86.56%, Learning rate: 0.001000,
Time: 23.76s
[Epoch: 43/50] Loss: 0.3918, Accuracy: 86.98%, Learning rate: 0.001000,
Time: 23.70s
[Epoch: 44/50] Loss: 0.3869, Accuracy: 86.74%, Learning rate: 0.001000,
Time: 24.03s
[Epoch: 45/50] Loss: 0.3876, Accuracy: 86.90%, Learning rate: 0.001000,
Time: 24.38s
[Epoch: 46/50] Loss: 0.3855, Accuracy: 86.91%, Learning rate: 0.001000,
Time: 24.37s
[Epoch: 47/50] Loss: 0.3851, Accuracy: 87.05%, Learning rate: 0.001000,
Time: 23.89s
[Epoch: 48/50] Loss: 0.3852, Accuracy: 86.87%, Learning rate: 0.001000,
Time: 23.72s
[Epoch: 49/50] Loss: 0.3778, Accuracy: 87.22%, Learning rate: 0.001000,
Time: 23.74s
[Epoch: 50/50] Loss: 0.3782, Accuracy: 87.32%, Learning rate: 0.001000,
Time: 23.96s
Test set accuracy: 87.25%
```

=== Running Experiment: Adam_StepLR ===
Model parameters: 1,149,770
Using Adam optimizer with learning rate: 0.001
Using StepLR scheduler with step_size=15, gamma=0.1
[Epoch: 1/50] Loss: 1.4760, Accuracy: 45.89%, Learning rate: 0.001000, Time: 23.83s
[Epoch: 2/50] Loss: 1.0977, Accuracy: 60.84%, Learning rate: 0.001000, Time: 23.97s
[Epoch: 3/50] Loss: 0.9327, Accuracy: 67.41%, Learning rate: 0.001000, Time: 24.07s
[Epoch: 4/50] Loss: 0.8310, Accuracy: 71.15%, Learning rate: 0.001000, Time: 23.85s
[Epoch: 5/50] Loss: 0.7598, Accuracy: 73.71%, Learning rate: 0.001000, Time: 24.24s
[Epoch: 6/50] Loss: 0.7124, Accuracy: 75.27%, Learning rate: 0.001000, Time: 23.77s
[Epoch: 7/50] Loss: 0.6721, Accuracy: 76.92%, Learning rate: 0.001000, Time: 24.44s
[Epoch: 8/50] Loss: 0.6393, Accuracy: 78.14%, Learning rate: 0.001000, Time: 24.27s
[Epoch: 9/50] Loss: 0.6106, Accuracy: 78.91%, Learning rate: 0.001000, Time: 23.78s
[Epoch: 10/50] Loss: 0.5898, Accuracy: 79.71%, Learning rate: 0.001000, Time: 23.86s
[Epoch: 11/50] Loss: 0.5703, Accuracy: 80.33%, Learning rate: 0.001000, Time: 23.83s
[Epoch: 12/50] Loss: 0.5560, Accuracy: 80.93%, Learning rate: 0.001000, Time: 23.96s
[Epoch: 13/50] Loss: 0.5405, Accuracy: 81.68%, Learning rate: 0.001000, Time: 23.83s
[Epoch: 14/50] Loss: 0.5242, Accuracy: 81.92%, Learning rate: 0.001000, Time: 24.42s
[Epoch: 15/50] Loss: 0.5113, Accuracy: 82.47%, Learning rate: 0.000100, Time: 23.77s
[Epoch: 16/50] Loss: 0.4055, Accuracy: 86.15%, Learning rate: 0.000100, Time: 23.84s
[Epoch: 17/50] Loss: 0.3688, Accuracy: 87.42%, Learning rate: 0.000100, Time: 23.89s
[Epoch: 18/50] Loss: 0.3507, Accuracy: 88.12%, Learning rate: 0.000100, Time: 23.92s
[Epoch: 19/50] Loss: 0.3392, Accuracy: 88.36%, Learning rate: 0.000100, Time: 24.33s

[Epoch: 20/50] Loss: 0.3337, Accuracy: 88.64%, Learning rate: 0.000100, Time: 24.09s
[Epoch: 21/50] Loss: 0.3181, Accuracy: 89.15%, Learning rate: 0.000100, Time: 24.11s
[Epoch: 22/50] Loss: 0.3156, Accuracy: 89.33%, Learning rate: 0.000100, Time: 23.70s
[Epoch: 23/50] Loss: 0.3093, Accuracy: 89.53%, Learning rate: 0.000100, Time: 23.80s
[Epoch: 24/50] Loss: 0.2991, Accuracy: 89.86%, Learning rate: 0.000100, Time: 23.64s
[Epoch: 25/50] Loss: 0.2957, Accuracy: 89.80%, Learning rate: 0.000100, Time: 23.89s
[Epoch: 26/50] Loss: 0.2910, Accuracy: 90.05%, Learning rate: 0.000100, Time: 23.66s
[Epoch: 27/50] Loss: 0.2832, Accuracy: 90.30%, Learning rate: 0.000100, Time: 23.81s
[Epoch: 28/50] Loss: 0.2819, Accuracy: 90.49%, Learning rate: 0.000100, Time: 23.80s
[Epoch: 29/50] Loss: 0.2726, Accuracy: 90.64%, Learning rate: 0.000100, Time: 23.94s
[Epoch: 30/50] Loss: 0.2681, Accuracy: 90.82%, Learning rate: 0.000010, Time: 24.46s
[Epoch: 31/50] Loss: 0.2518, Accuracy: 91.52%, Learning rate: 0.000010, Time: 24.27s
[Epoch: 32/50] Loss: 0.2476, Accuracy: 91.55%, Learning rate: 0.000010, Time: 23.72s
[Epoch: 33/50] Loss: 0.2478, Accuracy: 91.61%, Learning rate: 0.000010, Time: 23.78s
[Epoch: 34/50] Loss: 0.2454, Accuracy: 91.50%, Learning rate: 0.000010, Time: 23.91s
[Epoch: 35/50] Loss: 0.2462, Accuracy: 91.64%, Learning rate: 0.000010, Time: 24.08s
[Epoch: 36/50] Loss: 0.2417, Accuracy: 91.73%, Learning rate: 0.000010, Time: 23.73s
[Epoch: 37/50] Loss: 0.2403, Accuracy: 91.79%, Learning rate: 0.000010, Time: 24.07s
[Epoch: 38/50] Loss: 0.2381, Accuracy: 91.83%, Learning rate: 0.000010, Time: 23.93s
[Epoch: 39/50] Loss: 0.2414, Accuracy: 91.74%, Learning rate: 0.000010, Time: 24.01s
[Epoch: 40/50] Loss: 0.2394, Accuracy: 91.88%, Learning rate: 0.000010, Time: 23.74s

[Epoch: 41/50] Loss: 0.2364, Accuracy: 91.96%, Learning rate: 0.000010, Time: 24.17s
[Epoch: 42/50] Loss: 0.2358, Accuracy: 92.01%, Learning rate: 0.000010, Time: 24.33s
[Epoch: 43/50] Loss: 0.2353, Accuracy: 91.99%, Learning rate: 0.000010, Time: 23.81s
[Epoch: 44/50] Loss: 0.2369, Accuracy: 91.96%, Learning rate: 0.000010, Time: 24.01s
[Epoch: 45/50] Loss: 0.2357, Accuracy: 91.91%, Learning rate: 0.000001, Time: 24.17s
[Epoch: 46/50] Loss: 0.2308, Accuracy: 92.11%, Learning rate: 0.000001, Time: 24.02s
[Epoch: 47/50] Loss: 0.2333, Accuracy: 92.07%, Learning rate: 0.000001, Time: 24.03s
[Epoch: 48/50] Loss: 0.2347, Accuracy: 92.04%, Learning rate: 0.000001, Time: 23.85s
[Epoch: 49/50] Loss: 0.2288, Accuracy: 92.19%, Learning rate: 0.000001, Time: 23.66s
[Epoch: 50/50] Loss: 0.2331, Accuracy: 92.04%, Learning rate: 0.000001, Time: 24.46s
Test set accuracy: 90.48%

=== Running Experiment: Adam_CosineAnnealing ===
Model parameters: 1,149,770
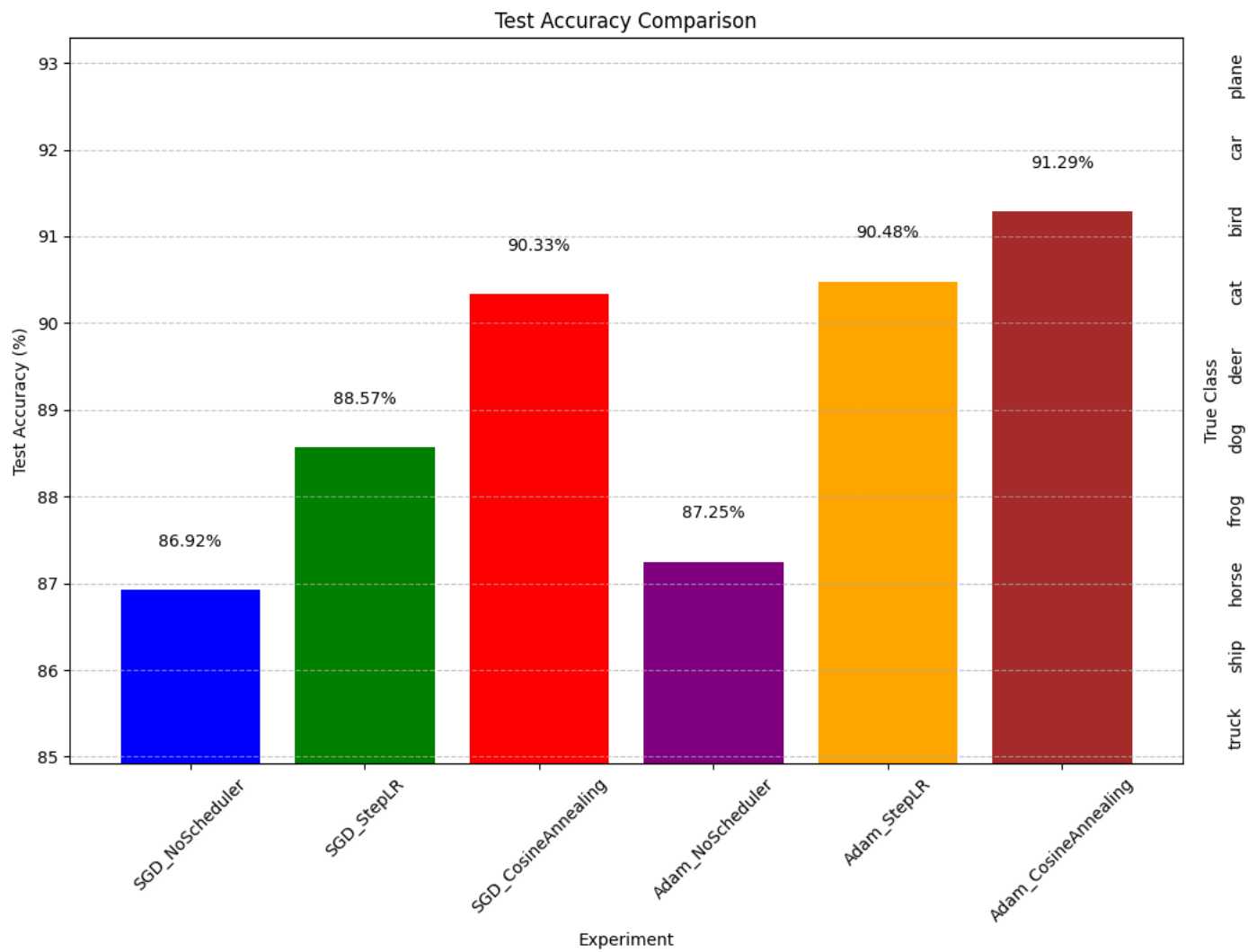Using Adam optimizer with learning rate: 0.001
Using CosineAnnealingLR scheduler with T_max=50
[Epoch: 1/50] Loss: 1.4764, Accuracy: 45.85%, Learning rate: 0.000999, Time: 24.30s
[Epoch: 2/50] Loss: 1.0927, Accuracy: 61.50%, Learning rate: 0.000996, Time: 23.83s
[Epoch: 3/50] Loss: 0.9319, Accuracy: 67.26%, Learning rate: 0.000991, Time: 23.75s
[Epoch: 4/50] Loss: 0.8285, Accuracy: 71.06%, Learning rate: 0.000984, Time: 24.22s
[Epoch: 5/50] Loss: 0.7588, Accuracy: 73.76%, Learning rate: 0.000976, Time: 24.31s
[Epoch: 6/50] Loss: 0.7077, Accuracy: 75.66%, Learning rate: 0.000965, Time: 23.91s
[Epoch: 7/50] Loss: 0.6696, Accuracy: 76.98%, Learning rate: 0.000952, Time: 23.73s
[Epoch: 8/50] Loss: 0.6316, Accuracy: 78.44%, Learning rate: 0.000938, Time: 23.76s

[Epoch: 9/50] Loss: 0.6012, Accuracy: 79.47%, Learning rate: 0.000922,
Time: 24.12s
[Epoch: 10/50] Loss: 0.5750, Accuracy: 80.19%, Learning rate: 0.000905,
Time: 23.89s
[Epoch: 11/50] Loss: 0.5618, Accuracy: 80.73%, Learning rate: 0.000885,
Time: 24.04s
[Epoch: 12/50] Loss: 0.5376, Accuracy: 81.56%, Learning rate: 0.000864,
Time: 24.57s
[Epoch: 13/50] Loss: 0.5150, Accuracy: 82.28%, Learning rate: 0.000842,
Time: 24.11s
[Epoch: 14/50] Loss: 0.5034, Accuracy: 82.63%, Learning rate: 0.000819,
Time: 24.23s
[Epoch: 15/50] Loss: 0.4822, Accuracy: 83.37%, Learning rate: 0.000794,
Time: 23.88s
[Epoch: 16/50] Loss: 0.4736, Accuracy: 83.98%, Learning rate: 0.000768,
Time: 23.79s
[Epoch: 17/50] Loss: 0.4558, Accuracy: 84.37%, Learning rate: 0.000741,
Time: 23.78s
[Epoch: 18/50] Loss: 0.4430, Accuracy: 84.91%, Learning rate: 0.000713,
Time: 24.20s
[Epoch: 19/50] Loss: 0.4333, Accuracy: 85.11%, Learning rate: 0.000684,
Time: 24.38s
[Epoch: 20/50] Loss: 0.4190, Accuracy: 85.76%, Learning rate: 0.000655,
Time: 24.01s
[Epoch: 21/50] Loss: 0.4051, Accuracy: 86.20%, Learning rate: 0.000624,
Time: 24.26s
[Epoch: 22/50] Loss: 0.3944, Accuracy: 86.63%, Learning rate: 0.000594,
Time: 24.35s
[Epoch: 23/50] Loss: 0.3838, Accuracy: 86.91%, Learning rate: 0.000563,
Time: 24.65s
[Epoch: 24/50] Loss: 0.3697, Accuracy: 87.38%, Learning rate: 0.000531,
Time: 24.19s
[Epoch: 25/50] Loss: 0.3590, Accuracy: 87.82%, Learning rate: 0.000500,
Time: 23.96s
[Epoch: 26/50] Loss: 0.3486, Accuracy: 87.93%, Learning rate: 0.000469,
Time: 23.94s
[Epoch: 27/50] Loss: 0.3405, Accuracy: 88.41%, Learning rate: 0.000437,
Time: 24.59s
[Epoch: 28/50] Loss: 0.3255, Accuracy: 88.84%, Learning rate: 0.000406,
Time: 24.66s
[Epoch: 29/50] Loss: 0.3131, Accuracy: 89.10%, Learning rate: 0.000376,
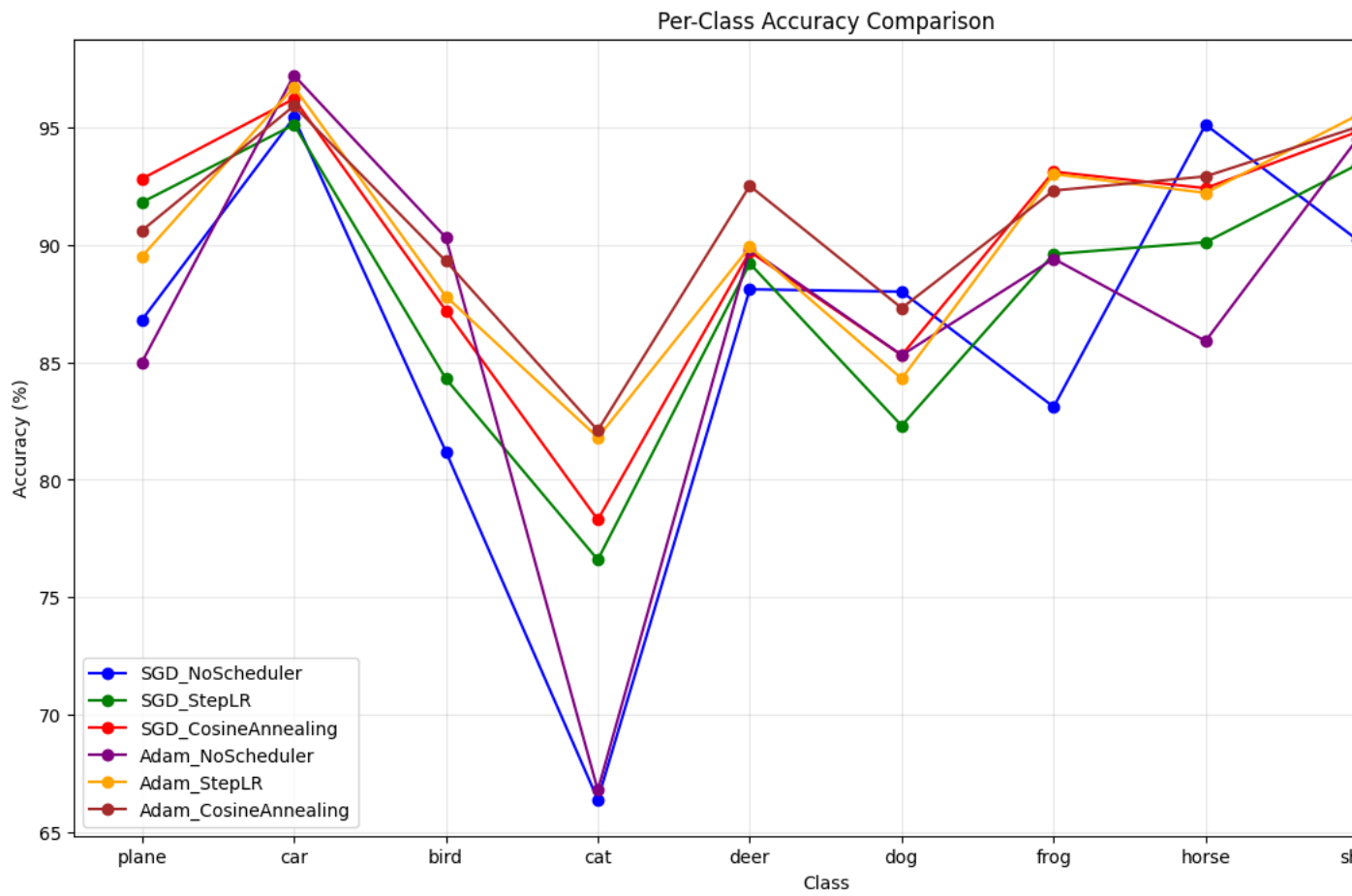Time: 24.45s

[Epoch: 30/50] Loss: 0.3012, Accuracy: 89.69%, Learning rate: 0.000345, Time: 24.30s
[Epoch: 31/50] Loss: 0.2925, Accuracy: 89.99%, Learning rate: 0.000316, Time: 24.27s
[Epoch: 32/50] Loss: 0.2802, Accuracy: 90.25%, Learning rate: 0.000287, Time: 24.35s
[Epoch: 33/50] Loss: 0.2724, Accuracy: 90.66%, Learning rate: 0.000259, Time: 24.33s
[Epoch: 34/50] Loss: 0.2562, Accuracy: 91.17%, Learning rate: 0.000232, Time: 24.39s
[Epoch: 35/50] Loss: 0.2442, Accuracy: 91.63%, Learning rate: 0.000206, Time: 24.80s
[Epoch: 36/50] Loss: 0.2364, Accuracy: 91.92%, Learning rate: 0.000181, Time: 24.54s
[Epoch: 37/50] Loss: 0.2230, Accuracy: 92.29%, Learning rate: 0.000158, Time: 24.51s
[Epoch: 38/50] Loss: 0.2156, Accuracy: 92.58%, Learning rate: 0.000136, Time: 24.48s
[Epoch: 39/50] Loss: 0.2076, Accuracy: 92.93%, Learning rate: 0.000115, Time: 24.38s
[Epoch: 40/50] Loss: 0.2006, Accuracy: 93.18%, Learning rate: 0.000095, Time: 24.76s
[Epoch: 41/50] Loss: 0.1932, Accuracy: 93.36%, Learning rate: 0.000078, Time: 24.74s
[Epoch: 42/50] Loss: 0.1835, Accuracy: 93.84%, Learning rate: 0.000062, Time: 24.32s
[Epoch: 43/50] Loss: 0.1783, Accuracy: 93.97%, Learning rate: 0.000048, Time: 24.32s
[Epoch: 44/50] Loss: 0.1741, Accuracy: 94.09%, Learning rate: 0.000035, Time: 24.55s
[Epoch: 45/50] Loss: 0.1693, Accuracy: 94.24%, Learning rate: 0.000024, Time: 24.24s
[Epoch: 46/50] Loss: 0.1663, Accuracy: 94.34%, Learning rate: 0.000016, Time: 23.92s
[Epoch: 47/50] Loss: 0.1624, Accuracy: 94.43%, Learning rate: 0.000009, Time: 24.67s
[Epoch: 48/50] Loss: 0.1609, Accuracy: 94.71%, Learning rate: 0.000004, Time: 24.31s
[Epoch: 49/50] Loss: 0.1573, Accuracy: 94.69%, Learning rate: 0.000001, Time: 24.86s
[Epoch: 50/50] Loss: 0.1575, Accuracy: 94.69%, Learning rate: 0.000000, Time: 24.13s
Test set accuracy: 91.29%

Training Loss Comparison

Test Accuracy Comparison

SGD_NoScheduler

True Class	plane	car	bird	cat	deer	dog	frog	horse	ship	truck
plane	868	10	23	12	11	2	1	19	23	31
car	2	954	0	0	1	0	0	3	1	39
bird	32	0	812	16	35	43	9	39	6	8
cat	9	7	40	664	26	172	9	44	10	19
deer	3	1	20	5	881	33	4	48	1	4
dog	5	3	16	45	14	880	0	32	1	4
frog	11	4	31	26	29	39	831	13	8	8
horse	3	0	6	4	14	19	0	951	0	3
ship	32	30	4	0	0	2	2	5	902	23
truck	7	32	1	2	1	0	0	5	3	949

Predicted Class

SGD_CosineAnnealing

True Class	plane	car	bird	cat	deer	dog	frog	horse	ship	truck
plane	928	5	25	5	3	2	2	3	19	8
car	7	962	0	0	1	1	1	1	4	23
bird	29	0	872	22	31	16	15	6	5	4
cat	7	2	34	783	26	95	20	18	6	9
deer	5	1	25	22	897	22	14	10	1	3

Per-Class Accuracy Comparison

```
=== All Experiments Completed ===
SGD_NoScheduler: Test Accuracy = 86.92%
SGD_StepLR: Test Accuracy = 88.57%
SGD_CosineAnnealing: Test Accuracy = 90.33%
Adam_NoScheduler: Test Accuracy = 87.25%
Adam_StepLR: Test Accuracy = 90.48%
Adam_CosineAnnealing: Test Accuracy = 91.29%
```