Kinematics Problems

1. You ride your bike for $1.5\ h$ at an average velocity of $10\ km/h$, then for $30\ min$ at $15\ km/h$. What is your average velocity? ($11.25\ km/h$)

2. Plot a velocity-time graph using the information in the table below, then answer the questions.

Velocity vs. Time			
Time (s)	**Velocity** (m/s)	**Time** (s)	**Velocity** (m/s)
0.0	4.0	7.0	12.0
1.0	8.0	8.0	8.0
2.0	12.0	9.0	4.0
3.0	14.0	10.0	0.0
4.0	16.0	11.0	–4.0
5.0	16.0	12.0	–8.0
6.0	14.0		

   a) During which time interval is the object speeding up? Slowing down? (speeding up from 0 to $4.0\ s$, slowing down from $5.0\ s$ to $10\ s$)

   b) At what time does the object reverse direction? ($10\ s$)

   c) How does the average acceleration of the object in the interval between 0 and $2\ s$ differ from the average acceleration in the interval between $7\ s$ and $12\ s$? ($4.0\ m/s^2$; $-4.0\ m/s^2$)

3. Find the uniform acceleration that causes a car's velocity to change from $32\ m/s$ to $96\ m/s$ in an $8.0\ s$ period. ($8.0\ m/s^2$)

4. A car with a velocity of $22\ m/s$ is accelerated uniformly at the rate of $1.6\ m/s^2$ for $6.8\ s$. What is its final velocity? ($33\ m/s$)

5. A supersonic jet flying at $145\ m/s$ is accelerated uniformly at the rate of $23.1\ m/s^2$ for $20.0\ s$.

   a) What is its final velocity? ($607\ m/s$)

   b) The speed of sound in air is $331\ m/s$. How many times the speed of sound is the plane's final speed? (1.83)

6. Determine the final velocity of a proton that has an initial velocity of $2.35\times10^5\ m/s$, and then is accelerated uniformly in an electric field at the rate of $-1.10\times10^{12}\ m/s^2$ for $1.50\times10^{-7}\ s$. ($7.0\times10^4\ m/s$)

7. Determine the displacement of a plane that is uniformly accelerated from $66\ m/s$ to $88\ m/s$ in $12\ s$. ($924\ m$)

8. How far does a plane fly in $15\ s$ while its velocity is changing from $145\ m/s$ to $75\ m/s$ at a uniform rate of acceleration? ($1650\ m$)

9. A car moves at $12\ m/s$ and coasts up a hill with a uniform acceleration of $-1.6\ m/s^2$.

   a) How far has it traveled after $6.0\ s$? ($43.2\ m$)

   b) How far has it traveled after $9.0\ s$? Explain. ($43.2\ m$)

10. A plane travels $500\ m$ while being accelerated uniformly from rest at the rate of $5.0\ m/s^2$. What final velocity does it reach? ($71\ m/s$)

11. A race car can be slowed with a constant acceleration of $-11\ m/s^2$.

    a) If the car is going $55\ m/s$, how many meters will it take to stop? ($137.5\ m$)

    b) How many meters will it take to stop a car going twice as fast? ($550\ m$)

12. An engineer must design a runway to accommodate airplanes that must reach a ground velocity of $61\ m/s$ before they can take off. These planes are capable of being accelerated uniformly at the rate of $2.5\ m/s^2$.

    a) How long will it take the planes to reach takeoff speed? ($24.4\ s$)

    b) What must be the minimum length of the runway? ($744\ m$)

13. Engineers are developing new types of guns that might someday be used to launch satellites as if they were bullets. One such gun can give a small object a velocity of $3.5\ km/s$, moving it through only $2.0\ cm$.

    a) What acceleration does the gun give this object? ($3.1\times10^{8}\ m/s^2$)

    b) Over what time interval does the acceleration take place? ($1.1\times10^{-5}\ s$)

14. Highway safety engineers build soft barriers so that cars hitting them will slow down at a safe rate. A person wearing a seat belt can withstand an acceleration of $-300\ m/s^2$. How thick should barriers be to safely stop a car that hits a barrier at $110\ km/h$? ($1.56\ m$)

15. A baseball pitcher throws a fastball at a speed of $44\ m/s$. The acceleration occurs as the pitcher holds the ball in his hand an moves it through an almost straight-line distance of $3.5\ m$. Calculate the acceleration, assuming it is uniform. ($277\ m/s^2$)

16. Rocket powered sleds are used to test the responses of humans to acceleration. Starting from rest, one sled can reach a speed of $444\ m/s$ in $1.80\ s$ and can be brought to a stop again in $2.15\ s$.

    a) Calculate the acceleration of the sled when starting. ($247\ m/s^2$)

    b) Calculate the acceleration of the sled when braking. ($-207\ m/s^2$)

17. **(Challenging)** The driver of a car going $90.0\ km/h$ suddenly sees the lights of a barrier $40.0\ m$ ahead. It takes the driver $0.75\ s$ to apply the brakes, and the average acceleration during braking is $-10.0\ m/s^2$.

    a) Determine whether the car hits the barrier.

    b) What is the maximum speed at which the car could be moving and not hit the barrier $40.0\ m$ ahead? Assume the rate of acceleration is the same. ($22\ m/s$)

18. **(Challenging)** As a traffic light turns green, a waiting car starts with a constant acceleration of $6.0\ m/s^2$. At the instant the car begins to accelerate, a truck with a constant velocity of $21\ m/s$ passes in the next lane.

    a) How far will the car travel before it overtakes the truck? ($147\ m$)

    b) How fast will the car be traveling when it overtakes the truck? ($42\ m/s$)