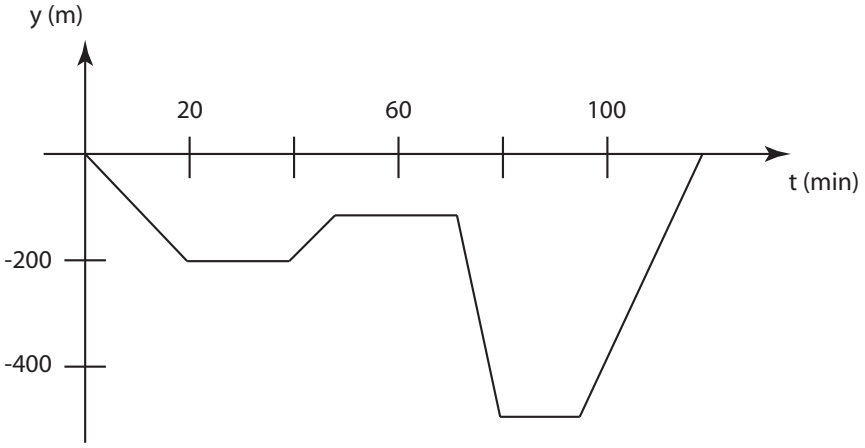
Problem Session
1D Kinematics

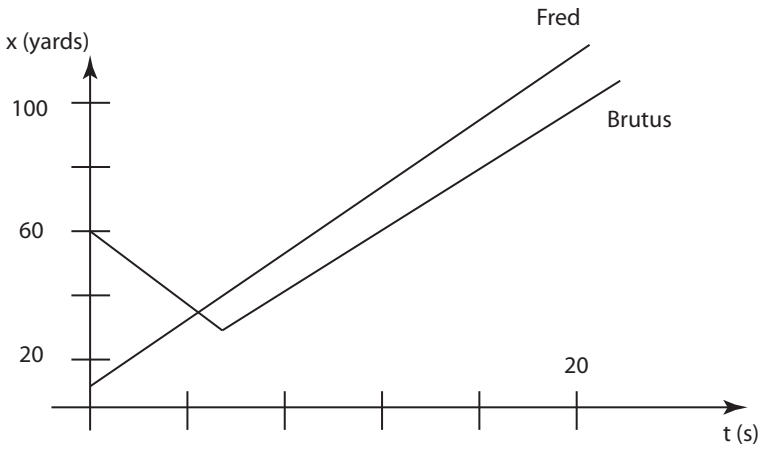
1. Draw the three motion diagrams (***x*** vs *t*), (***v*** vs *t*), and (***a*** vs *t*) for each of the following motion.
   a) A car accelerates forward from a stop sign, with a constant acceleration. It eventually reaches a steady speed of 50 km/h
   b) You are driving your car at a steady speed of 30 km/h when a small furry creature runs into the road in front of you. You hit the breaks and skid to a stop. Draw the motion diagrams from 2 seconds before you start breaking until you come to a stop.

2. Interpret the following position vs time graphs by writing short story of what is happening.

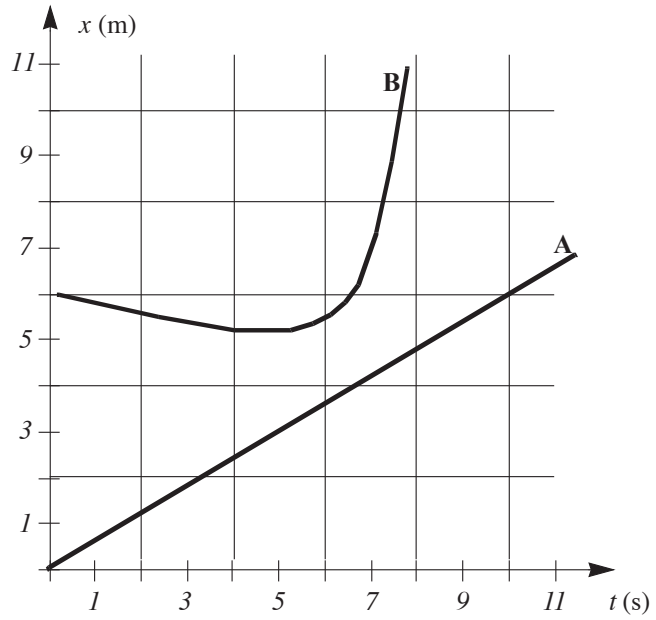
a) Submarine



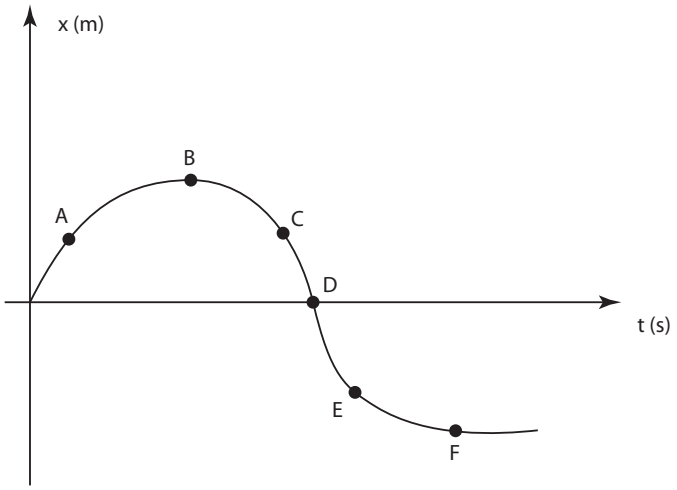
b) 2 football players



3. The following figure shows the position-time graph for two objects A and B that are moving along the same axis. At the instant t = 2 s, is the speed of A greater than the speed of B? ***Explain.***

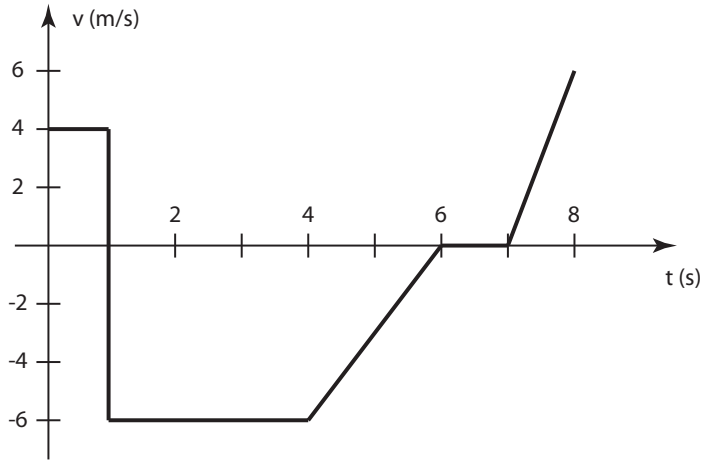


4. The following figure shows a position-time graph for a moving object. Assume that the direction toward the right of the page to be the positive direction. At which lettered point or points

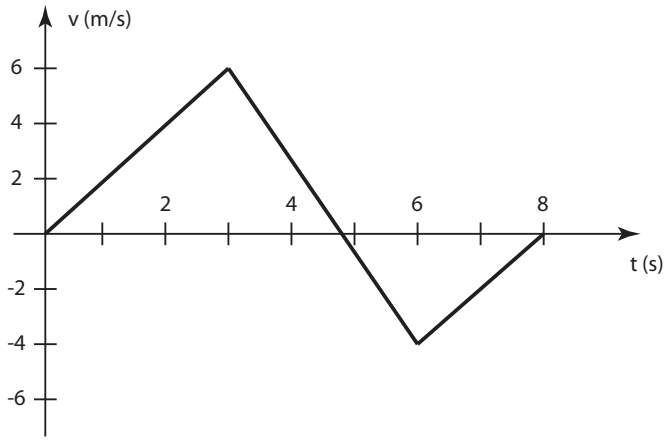


a) is the object moving the fastest?
b) is the object moving to the left?
c) is the object speeding up?
d) is the object slowing down?
e) is the object changing direction?

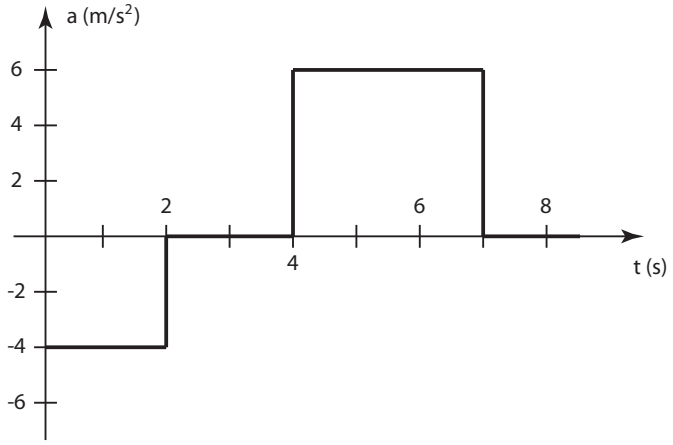
5. Below is a velocity-time graph. Draw the corresponding position-time graph.



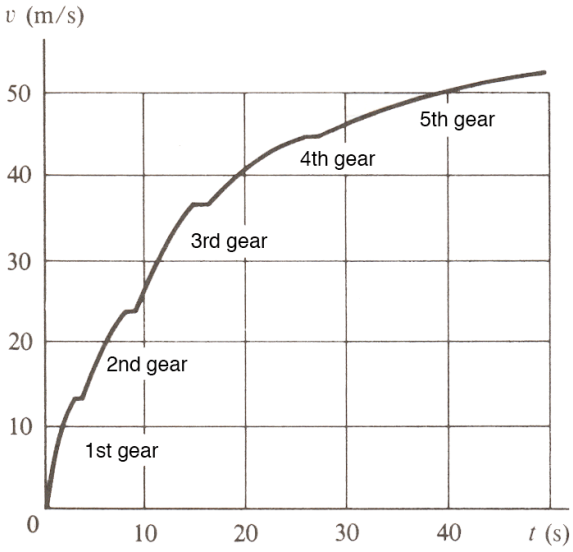
6. Below is a velocity-time graph. Draw the corresponding acceleration-time graph.



7. Below is an acceleration-time graph. Draw the corresponding velocity-time graph. Assume $v_i = 0$ m/s.



8. A 1986 Alfa Romeo (now a vintage car) can accelerate approximately as shown in the velocity-time graph below. (The short flat spots in the curve represent shifting of the gears).

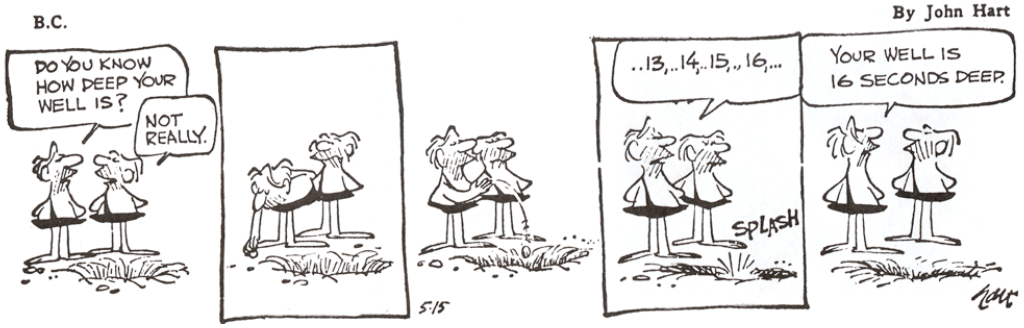


a) Estimate the average acceleration in second gear and in fourth gear.
b) What is the average acceleration through the first four gears?

9. A 200 kg weather rocket is loaded with 100 kg of fuel and fired straight up. It accelerates upward at 30 m/s^2 for 30 s, then runs out of fuel. Ignore any air resistance effects.
a) What is the rocket's maximum altitude?
b) How long is the rocket in the air?
c) Draw a velocity-time graph for the rocket from liftoff until it hits the ground.

10. A car starts at rest at a stop sign. It accelerates at 4.0 m/s^2 for 6 seconds, coasts for 2 s, and then slows down at a rate of 3.0 m/s^2 for the next stop sign. How far apart are the stop signs?

11. The following situation happened a long long time ago...



The speed of sound is considered constant at 343 m/s and,
a) calculate how deep is the well.
b) What is the velocity of the rock when it hits the water.

12. You want to visit your friend in Toronto during the long weekend. To save money you decide to travel there by train. Unfortunately your physics exam took the full period, so you are late in arriving at the train station. You run as fast as you can, but just as you reach the platform you see your train, 30 m ahead of you down the platform, begin to accelerate at 1.0 m/s^2. You chase after the train at your maximum speed of 8.0 m/s, but there's a barrier 50 m ahead. Will you be able to leap onto the back of the train before you crash into the barrier?

13. ***Frathouse.*** The faculty resident of a dormitory sees an illegal water-filled ballon fall vertically past his window. Having lightning reflexes, he observes that the ballon took 0.15 s to pass from top to bottom of his window–a distance of 2 m. Assuming the ballon was released from rest, how high above the bottom of his window was the guilty party?

14. ***Speeding can kill you!*** Two cars are travelling, one behind the other, on a straight road. Each has a speed of 21 m/s and the distance between them is 25 m. The driver of the rear car decides to overtake the car ahead and does so by accelerating at 2 m/s^2 up to 30 m/s after which he continues at this speed until he is 25 m ahead of the other car.
    a) How far does the overtaking car travel along the road between the beginning and end of this operation?
    b) If a third car were in sight, coming in the opposite direction at 25 m/s, what would be the minimum safe distance between the third car and the overtaking car at the beginning of the overtaking operation? (If you are a driver, take note of how large this distance is.)

15. An object is thrown vertically upward from a 10 m cliff with a speed of 5 m/s. It later falls into a tank of water 10 m below the edge of the cliff and 5 m deep. It falls through this tank for a time of 0.4 s before hitting the bottom.
    a) Find the maximum height reached by the object and the acceleration in the water.
    b) What was the velocity of the object when it hit the bottom of the pool?

Answers

9. The rocket reaches a maximum altitude of 54 826 m, and remains in the air for 228 s before crashing.

10. The stops signs are 216 m apart.

11. The well is 883 m deep and the rock hits the water with a velocity of 132 m/s downward.

12. You will be able to leap on the train in 6 s, 2 m before the barrier.

13. The culprit was 10.1 m above the bottom of the faculty resident's window.

14. The overtaking car travels 214 m before changing back into its lane, making the minimum safe distance with the incoming car to be 410 m.

15. The object reaches a height of 1.28 m above the edge of the cliff before falling back down and hitting the top of the pool at a speed of 14.9 m/s. The acceleration in the pool is 11.8 m/s^2 upward (since it slows down the object) and it hits the bottom with a speed of 10.1 m/s.