Motion Equations **NOTE: x and d are both variables for distance. Either may be used.**

Special case when a=g, up and down problems, parabolic motion

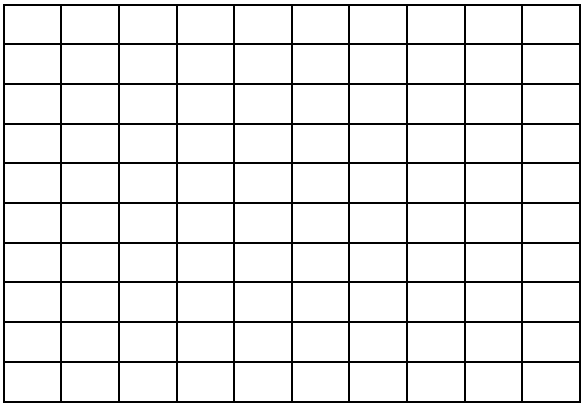
Kinematics
REMEMBER DISTANCE MY BE INDICATED BY EITHER X OR D
LEFT is negative, DOWN is negative

Formulae to consider:
When a=0, the velocity is constant, so $d = v\,\Delta t$ $x_f = x_i + \bar{v}t$

1. Refer to the chart below with data about a moving object.

Time elapsed (s)	0.0	6.54	14.2	21.9	37.3	60.4
Distance traveled (m)	1.5	10.0	20.0	30.0	50.0	80.0m

Sketch a position-time graph based on the data in the chart above.



What is the average velocity of the object?

2. A girl rides her bike at 6.3m/s for 20 min. How far does she travel in that time?
3. How fast would she be travelling if she had traveled 5.00 km in 11 minutes? (Express in m/s)

When a≠0, v is not a constant

$\Delta \mathbf{x} = \frac{(\mathbf{v_f}+\mathbf{v_i})}{\mathbf{2}}\,\mathbf{t}$ $v=a\Delta t$ $v_f = v_i + at$ $x_f = x_i + v_i t + \frac{1}{2} at^2$ $v_f^2 - v_i^2 = 2a\,(x_f - x_i)$

4. A racer accelerates from a stop to 50m/s over 0.5km. What is the racer's acceleration?

5. A fighter jet accelerates at 3g's where $1g=9.9 m/s^2$. If the jets initial speed is 110m/s , what is its speed after a 2.8s acceleration?

6. When the jet lands, it must slow from 80m/s to 0m/s over a distance of 1200m. What it its acceleration?

7. The position-time data sets below represent the motion of four objects.

Set 1		Set 2		Set 3		Set 4	
t(s)	d(m)	t(s)	d(m)	t(s)	d(m)	t(s)	d(m)
Data Set A		Data Set B		Data Set C		Data Set D	
t(s)	p(m)	t(s)	p(m)	t(s)	p(m)	t(s)	p(m)
0	3	0	0	0	8	0	4
1	5.15	1	-1.6	1	6.25	1	5.6
2	8.4	2	-3.2	2	4.2	2	7.2
3	12.75	3	-4.8	3	1.85	3	8.8
4	18.2	4	-6.4	4	-0.8	4	10.4
5	24.75	5	-8	5	-3.75	5	12

a. Which show motion to the left?
b. Which show motion to the right?
c. Which show acceleration?
d. Which show acceleration to the left?
e. Which show acceleration to the right?
f. Which show the action of a force acting upon them?

8. A marble rolls down a ramp with an acceleration of $3m/s^2$, it takes 1.85s to reach the bottom. How long is the ramp?

9. Consider 2 cars: The first car cruises up to a light that has just changed with a velocity of 7.5 m/s as it enters the intersection and then accelerates at $2m/s^2$. The second car was stopped at the light and then accelerates at $3m/s^2$.

- How far will each have travelled in 10.0.s?

When doing calculations for things that are moving up and down (Parabolic motion), $a=-9.8m/s^2$
Velocity at the top of the flight is zero
Free fall (dropping from a given height, starts at zero m/s (unless otherwise stated)

Initial vertical velocity=0: $t = \sqrt{\frac{2d}{g}}$ $d_x = v_x t$

Initial vertical velocity≠0: When launch height = final height:

$v_{y(top)}=0$ $\mathbf{t} = \frac{-v_{yf}}{g}$ $\mathbf{t\uparrow} = \mathbf{t\downarrow} = \frac{-v_{yi}}{g}$

Hang time is the total time in the air (time up plus time down)

10. On a planet with a gravitational acceleration of $5.3m/s^2$, how long will it take a bowling ball to fall 3.5m?

What will its velocity be when it hits?

11. An astronaut on a new planet wants to re-enact the famous eagle feather drop from the Apollo moon landings. The feather takes 2.9 to fall 1.9m. What is the acceleration due to gravity on the planetoid? (There is no atmosphere)

When combining horizontal and vertical motion, vertical motion will always be accelerated by the force due to gravity. Horizontal motion will only by accelerated if there is an accelerating force cited. Expect that horizontal motion is not accelerated.

$v_{xi} = v_{xf}=v_x =v_i\cos\theta$ $v_{yi} = v_{yf} = v_i\sin\theta$ **All other accelerated motion formulae apply**

MOTIONS IN THE X AND Y DIRECTIONS ARE ALWAYS INDEPENDENT OF EACH OTHER!!!

12. The rocket club has a new air rocket that will launch at 30.0m/s. They launch it straight up.
How high will it go and what will its hang time be, if it does not have a parachute?

13. The rocket club launches their new rocket at 30.0m/s and 70˚ from the horizontal
How high will it go and what will its hang time be, if it does not have a parachute?

14. A student uses a marble shooter to launch a marble straight off a table that is .85 m above the floor. It is moving at 8m/s and hits the wall which is 2.63m from the table. It leaves a small hole in the hits the wall. How high up the wall from the floor is the hole?

15. The student takes the marble launcher outside and wants to get the marble to go as far as possible. The student can only launch the marble horizontally. How can the student maximize the distance the marble will travel?

Force Equations

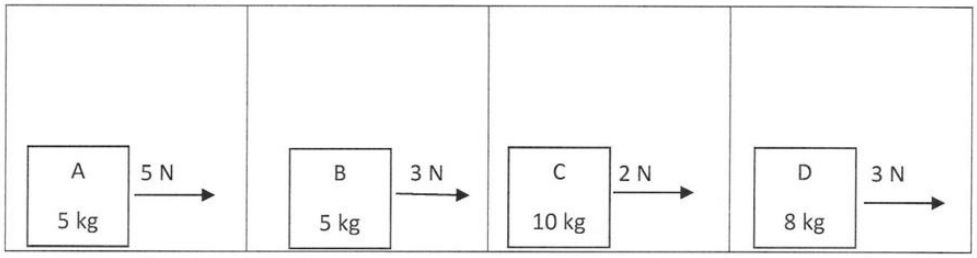
Forces

General Forces These are all modifications of Newton's second Law

$\Sigma F = ma$ $F_g = mg$ $F_f = \mu F_N$ $F_n = mg\cos\theta$

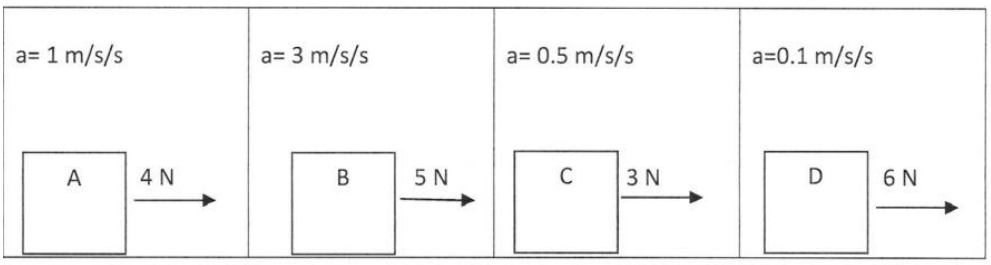
16.

In the following boxes, the pulling force and mass of the boxes is shown. There is no friction. Rank the acceleration of each box from greatest to least. Show if there are any ties, if any have the same acceleration.



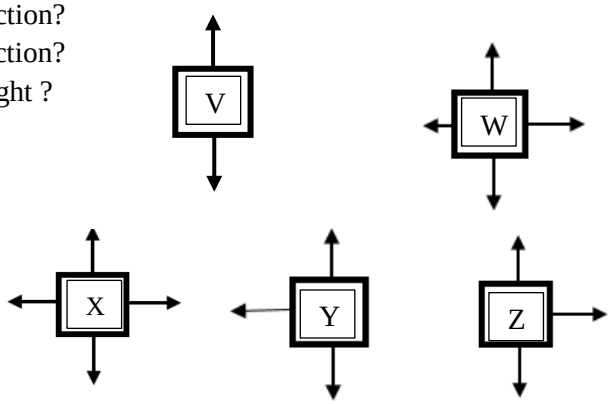
17.

Rank the following boxes based on their masses from greatest mass to least mass.



18. The diagrams below depict the individual forces acting upon an object. Each arrow represents a force and the length of the arrow represents the size of the force.

    a. Which diagram represents a balanced set of forces?
    b. Which could represent a constant motion in the x direction?
    c. Which could represent a constant motion in the y direction?
    d. Which could represent increased acceleration to the right ?
    e. Which could represent slowing down to the left ?
    f. Which could represent a constant speed to the right
    g. Which could represent a constant speed to the left



19. How are kg and N related? How are weight and mass related?
    a. What is the mass of a 57N object on earth?
    b. What is the weight of a 37kgobject on earth?
    c. What is the mass of a 118kg object on the moon?

20. What is the force applied on a 97 kg object that accelerates from rest to 15 m/s in 8 seconds?

21. What is the acceleration of a 35kg object if 15N is applied to it at 25˚ to the vertical on a frictionless surface?

22. What is the acceleration of a 75kg object if 30N is applied to in the direction of motion, but it is on a surface with a coefficient of friction that is 0.64?

Forces in more than one direction Note: Σ means "sum of" or "net)

General x and y statement: $\Sigma F_x = F_f$ + any other forces in the y direction $\Sigma F_y = F_N + F_g$ +any other forces in the y direction

Equilibrant Forces and Equilibrium:

$F_{adj} = F\cos\theta$ $F_{opp} = F\sin\theta$ $a = g[\sin\theta - \mu\cos\theta]$

$\Sigma F_x = F_{x1} + F_{x2} + F_{x3} + \ldots$ $\Sigma F_y = F_{y1} + F_{y2} + F_{y3} + \ldots$

23. What is the coefficient of friction of a level surface if a 60 kg tray is accelerated at 1.3 m/s² when it is pulled by a rope with tension 200 N at 30 degrees to the vertical across the table?

24. Calculate the amount of force needed to move a 45 kg object up a 20° frictionless incline at a constant speed.

Momentum Equations

Momentum = mv Impulse = FΔt FΔt = mΔv

Collisions

Elastic Collision (general statement): NOTE: i means initial(Before collision), f means final (After collision)

$$m_a v_a^i + m_b v_b^i = m_a v_a^f + m_b v_b^f$$

Inelastic Collision (when objects in the system either stick to each (caseI) other or separate(caseII))

Case I: $m_a v_a^i + m_b v_b^i = (m_a + m_b)v^f$ ***Case II***: $(m_a + m_b)v^i = m_a v_a^f + m_b v_b^f$

Impulse Momentum Theorem

25. A ball is dropped 0.80m onto a force meter and the force and time are determined as it stops. The impulse is calculated at 1.0Ns. What is the mass of the ball? (You need to use kinematics here as well as IMT)

26. Two 3.8 kg balls are moving at 1.3m/s to the right. The first hits a barrier and bounces back to the left at .37m/s. The second receives an impulse to the right and has a final speed of 1.8m/s. What is the change in momentum for each ball?

One dimensional Collisions:

27. Consider the following elastic collisions, which will produce the greatest post collision for the second cart?

In all cases the second cart is initially at rest and all have the same mass.

a. 5kg → 5m/s

b. 5kg → 3m/s

c. 2 kg → 5m/s

d. 2kg → 3m/s

28. A student puts a projectile launcher on a nearly frictionless plate. The plate and projectile launcher have a mass of 2.5 kg. When the projectile launcher shoots a 0.20kg pellet at 25m/s to the left. What is the final velocity of the launcher and plate?

29. Before a collision, two objects have a momentum of 16kgm/s. What is the total momentum of the two objects after the collision?

30. A wooden sphere with a mass of 53.0 g rolls along a frictionless surface at 12.0 m/s and strikes a stationary sphere having a mass of 120.0g. The first sphere stops completely. At what speed does the second sphere move away from the point of impact?

31. An arrow with a mass of 32 g hits an apple on the target. The arrow sticks in the apple and both fly off the target together. The total mass of arrow and apple is 250g. The arrow and apple leave the target with a velocity of 10m/s. How fast was the arrow moving at the moment of impact?

32. A Christmas train has cars that will link using magnets. One car has a mass of 0.35kg and is moving at 0.15m/s, the second car has a mass of 0.70kg and is stationary. After they hit and connect, what speed will they move at?

Two dimensional collisions

33. An object with a momentum of 1.86kgm/s strikes a second identical object that is at rest. They two objects move off at angles to the left and right of the original object.
    a. What do you know about the angles at which each moves?
    b. What do you know about the total momentum in the x direction?
    c. What do you know about the total momentum in the y direction?

34. Two identical balls are on a frictionless horizontal tabletop. The first initially moves at 6.0m/s It then collides elastically with a second, identical ball which is initially at rest. After the collision, the first ball moves at 25˚ to the left at 5.6m/s. At what speed and at what angle does the second ball move?

Energy and Work Equations

$W = Fd = mgd$ Work at an angle $= Fd\cos\theta = mgd\cos\theta$ $P = W/t = (Fd)/t = (mgd)/t$

$PE = m \times g \times h$ $KE = \frac{1}{2}mv^2$ Hooke's Law $F = -k x$

$Work = \Delta KE = KE_f - KE_i$ Conservation of Energy $KE_1 + PE_1 = KE_2 + PE_2$

Work Energy Theorem

35. Kay rolls a 7.0kg bowling ball with a force of 70N over a distance of 0.4m. What is the change in kinetic energy of the ball?

36. Define work. When can force be exerted without work being done?

37. A tow truck pulls a car with a force of 2000 N at 55° over a distance of 20 m. If there is a 400 N frictional force on the car, what is the change in kinetic energy of the car after the 20 m?

38. August cuts the lawn by pushing the lawn mower with a force of 50 N at a 70° over a distance of 1.5km. How much work has he done?

Collisions and springs

39. Describe four observations that you could make of a collision that would tell you that energy has been transferred

40. Springs:
    a. Find the spring constant for each of these and rank the spring constant from lowest to highest.

Ranking (lowest to highest)	Mass	Distortion	Spring Constant
	250g	7.8cm	
	500g	1.2m	
	1.30kg	.58m	
	0.1kg	10.5cm	

b. Find the spring constant for each of these and rank the spring constant from lowest to highest.

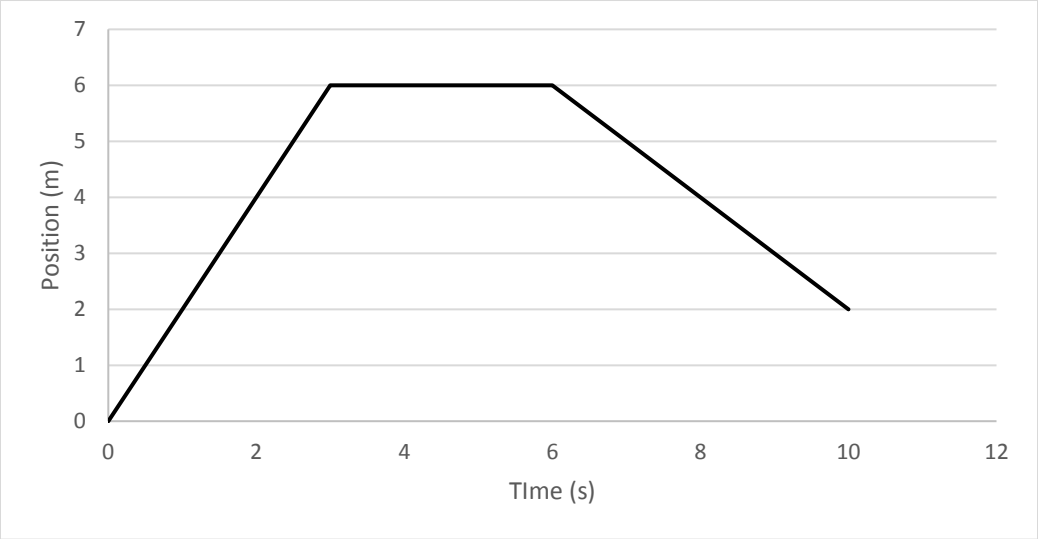
Ranking (lowest to highest)	Mass	Distortion	Spring Constant
	250g	12cm	
	500g	12m	
	1.30kg	12m	
	0.1kg	12cm	

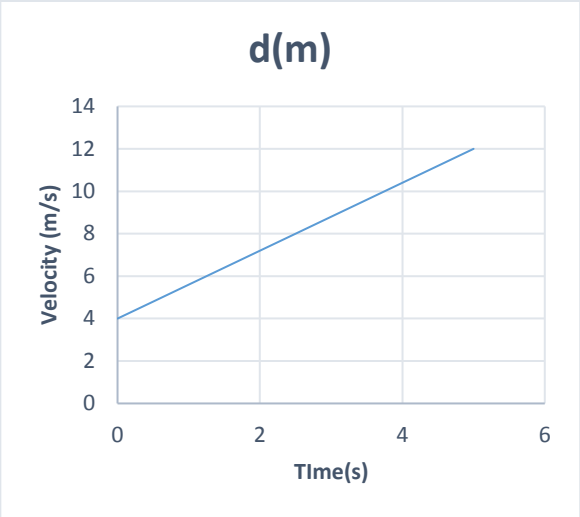
Graphs

1. Sketch the following pt and vt charts(right is positive, left is negative):
   a. vi is positive, a is positive and constant
   b. vi is positive, a is negative and constant
   c. vi is positive, a is zero
   d. vi is negative, a is positive and constant
   e. vi is negative, a is negative and constant
   f. vi is negative, a is zero
   g. vi is zero, a is positive and constant
   h. vi is zero, a is negative and constant
   i. vi is zero, a is zero

How would each of these 18 charts change if initial position was positive, negative or zero?

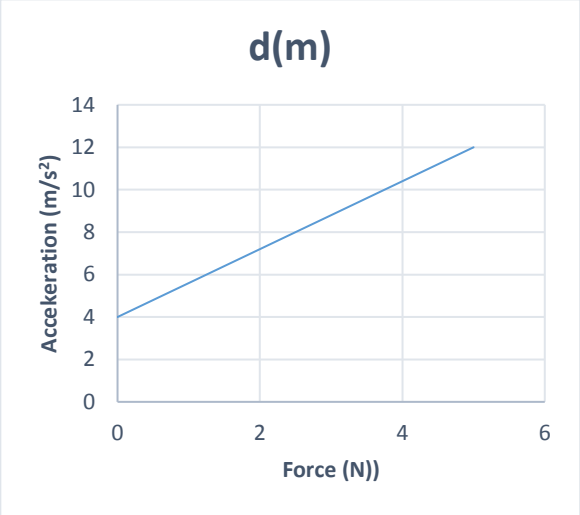
2) Describe the objects motion from time =0s to time =10s





3) Write the general equation and specific equation for this graph.

4. At what time before the start (t=0) was the object at 0m?

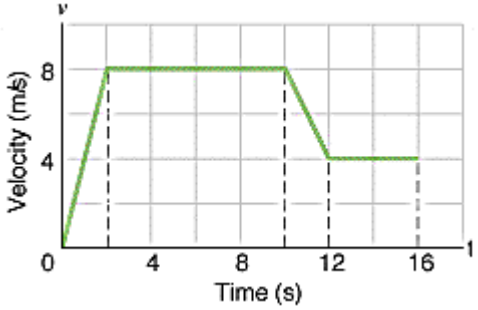


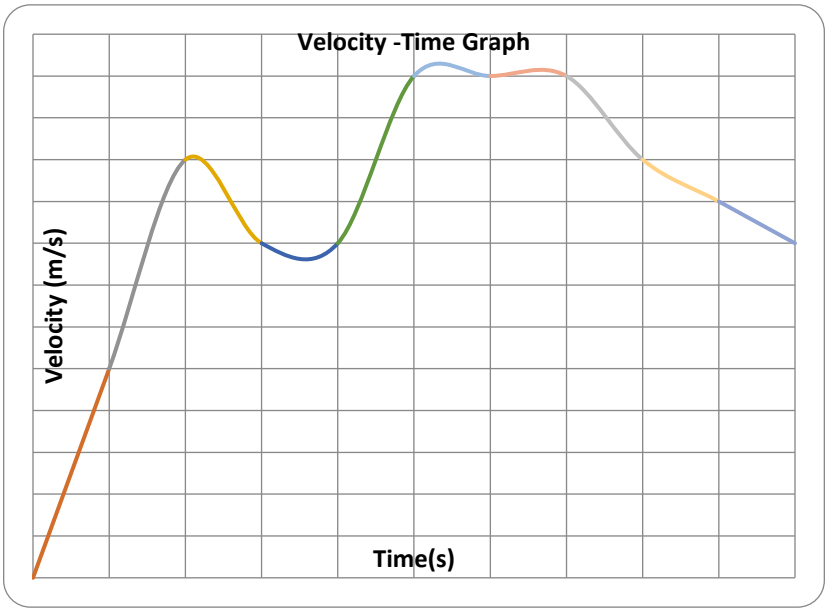
5. What does the slope of this graph represent? What are the units of this quantity?

6. a. At which time in this graph is the force directed to the right?

b. At which time in this graph is the force directed to the left?

c. At which time in this graph is there no net force?





7. a. At which time(s) in this graph is the force directed to the right?

b. At which time(s) in this graph is the force directed to the left?

c. At which time in this graph is there mechanical equilibrium?

Time starts at 0, then increases by 2 second intervals.

Equations

1. A rocket sled accelerates at $50 m/s^2$ from rest to a final speed in 3.3s. What equation could be used to find the final velocity of the rocket sled?

2. What equation could be used to find the distance travelled in this time?

3. Solve the following equation for vf, if both initial velocity and position are zero. $v_f^2 - v_i^2 = 2a\,(x_f - x_i)$

4. Combine $F_{net}=ma$ and $F_f=\mu mg(\cos\theta)$ to solve for the coefficient of friction for a block that is coasting to a stop on a level surface. Simplify the equation.

5. What is the speed of the object with mass b after an elastic collision, if it initially is at rest?

6. What is the speed of the object with mass b after an inelastic collision, if it initially is at rest?