Unit Review: Kinematics and Dynamics

1.1 Kinematics

Be able to:

- convert units
- add and subtract vectors using diagrams, trigonometry, and the component method
- define all terms related to an object's motion (e.g. displacement, velocity, acceleration, etc.)
- analyze position-time graphs
- analyze velocity-time graphs
- convert one type of motion graph into the other
- solve problems using the kinematics equations
- solve relative motion problems using vector addition (including non-right angled problems)

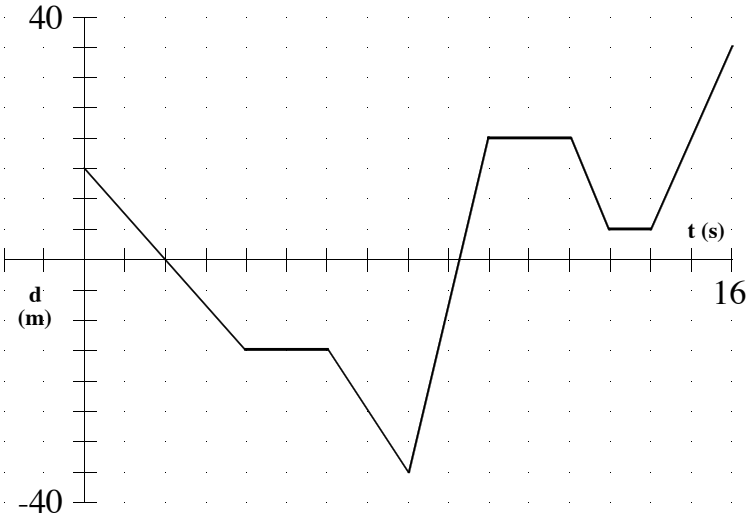
1.2 Dynamics

Be able to:

- state and explain Newton's three laws of motion
- solve equilibrium problems using vector addition and Newton's 1st law
- draw free body diagrams for
    - objects on horizontal surfaces
    - objects on inclined planes
    - hanging mass problems
- solve dynamics problems involving friction (for all of the problem types listed above)

Problems

Use the following position-time graph to answer questions 1 to 3.

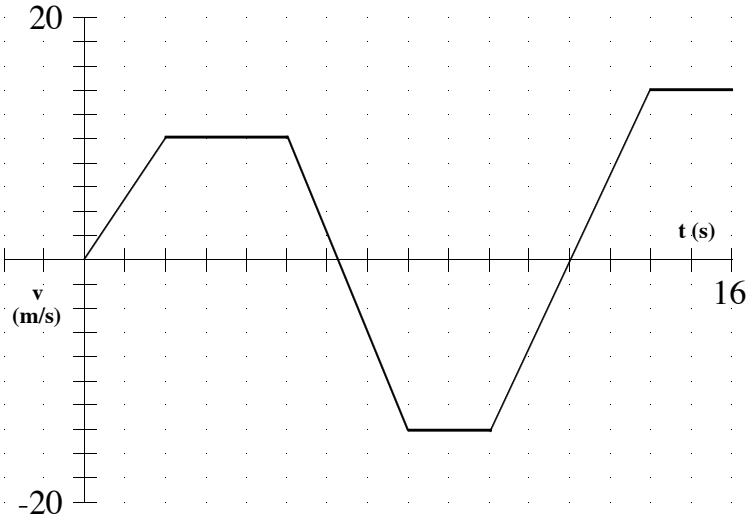


1. Describe the motion of the object from $t = 0$ to $t = 16\ s$.

2. Determine the velocity of the object in each interval.

3. Determine the average velocity from $t = 4\ s$ to $t = 12\ s$.

Use the following velocity-time graph to answer questions 4 to 6.



4. Describe the motion of the object from $t = 0$ to $t = 16\ s$.

5. Determine the acceleration of the object in each interval.

6. Determine the displacement of the object over the entire interval.

7. From the moment a $40\ m/s$ fastball touches the catcher's mitt until it is completely stopped takes $0.012\ s$. Calculate the average acceleration of the ball as it is being caught. $(-3333.\overline{3}\ m/s^2)$

8. A jet plane traveling at $+88\ m/s$ lands on a runway and comes to rest in $11\ s$.

   a) Calculate its acceleration as it stops. $(-8.0\ m/s^2)$

   b) Calculate the displacement it travels while braking. $(484\ m)$

9. A bullet accelerates at $6.8\times10^4\ m/s^2$ from rest as it travels the $0.80\ m$ of the rifle barrel.

   a) How long was the bullet in the barrel? $(4.85\times10^{-3}\ s)$

   b) What velocity does the bullet have as it leaves the barrel? $(329.8\ m/s)$

10. Police find skid marks $60\ m$ long on a highway showing where a car made an emergency stop. Assuming that the acceleration was $-10\ m/s^2$ (about the maximum for dry pavement), how fast was the car going? Was the car exceeding the $80\ km/h$ speed limit? $(34.6\ m/s$ or $124.7\ km/h)$

11. A speeding motorist passes a stopped police car. At the moment he passes, the police car begins accelerating at a constant rate of $4.4\ m/s^2$. The motorist, unaware that he is being chased, continues at constant speed until the police car catches him $12\ s$ later. How fast is the motorist going? $(26.4\ m/s$ or $95\ km/h)$

12. A camera is accidentally dropped from the edge of a cliff and $6.0\ s$ later hits the bottom.

   a) How fast was it going just before it hit? $(-58.8\ m/s)$

   b) How high is the cliff? $(176.4\ m)$

13. A rock is thrown vertically with a velocity of $20\ m/s$ from the edge of a bridge $42\ m$ above a river. How long does the rock stay in the air? $(5.61\ s)$

14. A $5.2\ kg$ bowling ball is accelerated from rest to a velocity of $12\ m/s$ as the bowler covers $5.0\ m$ of approach before releasing the ball. What force is exerted on the ball during this time? $(74.9\ N)$

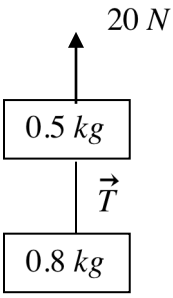
15. A high jumper, falling at $4.0\ m/s$, lands on a foam pit and comes to rest, compressing the pit $0.40\ m$. If the pit is able to exert a net force of $1200\ N$ on the high jumper in breaking the fall, what is the jumper's mass? $(60\ kg)$

16. A brick layer applies a force of $100\ N$ to each of two handles on a wheelbarrow. Its mass is $20\ kg$ and it is loaded with 30 bricks, each of mass $1.5\ kg$. The handles of the wheelbarrow are inclined at $30°$ from the horizontal and the coefficient of friction is 0.20. What is the acceleration of the wheelbarrow? ($0.40\ m/s^2$)

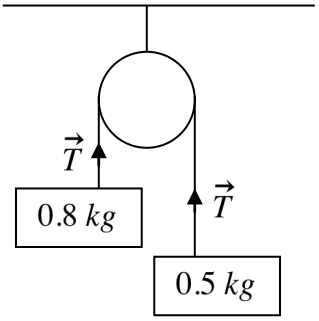
17. A box is given a push so that it slides across the floor. How far will it slide, given that the coefficient of friction is 0.30 and the push imparts an initial speed of $3.0\ m/s$? ($1.53\ m$)

18. Find the acceleration and tension in the cord in the following systems.

a)



b)



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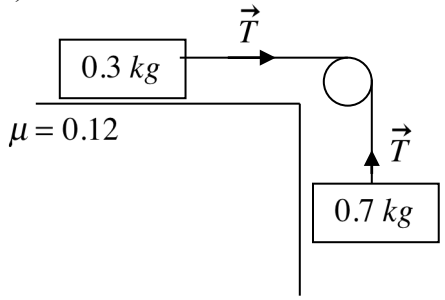

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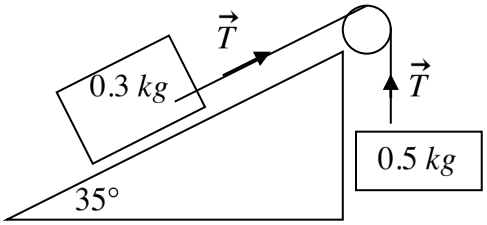

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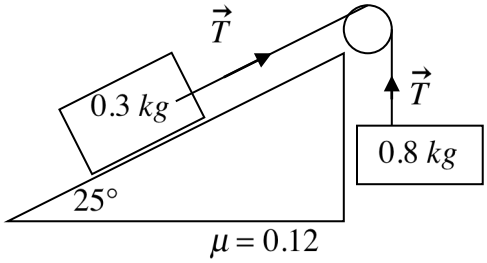
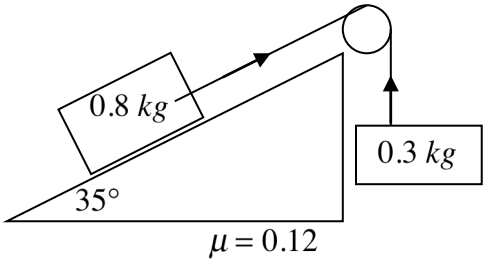


f)



a) $5.58\ m/s^2\ [up]$, $T = 12.3\ N$

b) $2.26\ m/s^2\ [ccw]$, $T = 6.03\ N$

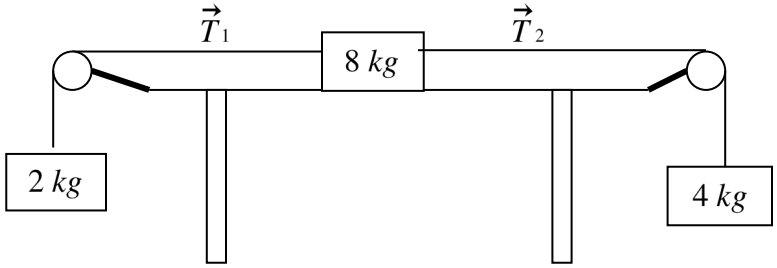
c) $6.51\ m/s^2\ [cw]$, $T = 2.31\ N$

d) $4.02\ m/s^2\ [cw]$, $T = 2.89\ N$

e) $5.71\ m/s^2\ [cw]$, $T = 3.27\ N$

f) $0.71\ m/s^2\ [ccw]$, $T = 3.15\ N$

Use the following diagram to answer questions 19 and 20.



19. Find the acceleration and both tension forces, assuming no friction. ($1.4\ m/s^2\ \left[cw\right]$, $T_1 = 22.4\ N$, $T_2 = 33.6\ N$)

20. If the coefficient of friction between the table and the 8 kg mass is 0.15, find the acceleration and both tension forces. ($0.56\ m/s^2\ \left[cw\right]$, $T_1 = 20.7\ N$, $T_2 = 37\ N$)