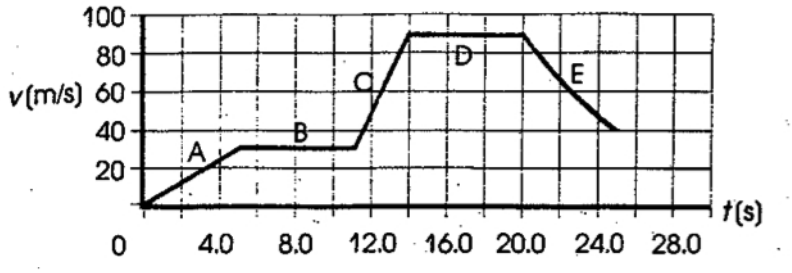
Exam Review
Problem Set 1 (Mechanics)

1. The velocity-time graph below represents the motion of a car. Assume that north is positive.



a) In which interval(s) is the velocity uniform?

b) In which interval(s) is the acceleration uniform?

c) How far has the car traveled after

i) $11\ s$?

ii) $25\ s$?

d) How far did the car travel in the 13^{th} second?

e) What is the acceleration

i) in the first $5.0\ s$?

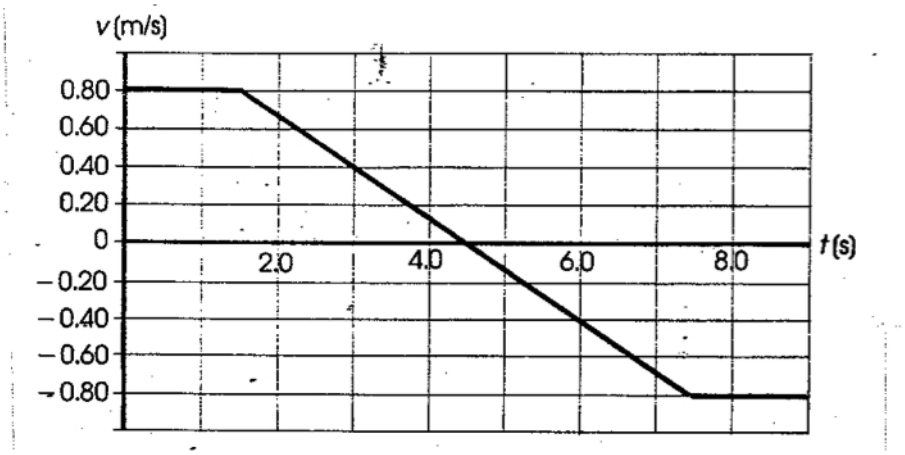
ii) from $t = 11\ s$ to $t = 14\ s$?

f) What is the instantaneous acceleration at

i) $t = 12.5\ s$?

ii) $t = 22\ s$?

2. A ball rolls along the floor, up a sloping board, and then back down the board and across the floor again. The graph below represents the motion.



a) At what time is the ball at its highest point?

b) What was the acceleration when the ball was

i) rolling up the board?

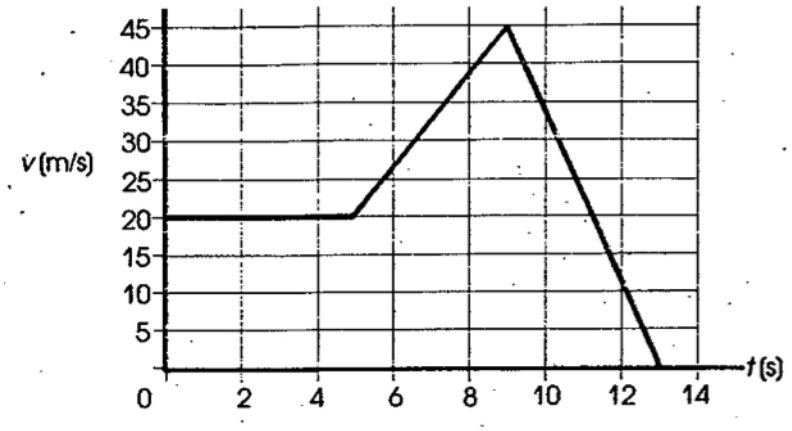
ii) rolling down the board?

iii) at rest at the top point?

c) How far up the board did the ball go?

d) What was the total displacement of the ball over the 9.0 *s* trip?

3. This graph describes the motion of a car.



a) What is the instantaneous acceleration at

i) $t = 3.0\ s$?

ii) $t = 7.0\ s$?

iii) $t = 11.0\ s$?

b) How far does the car travel in the first

i) $5.0\ s$?

ii) $9.0\ s$?

iii) $13.0\ s$?

4. When a batter hits a baseball its velocity is changed from $128\ km/h$ due west to $136\ km/h$ due east. (a) What is the change in speed? (b) What is the change in velocity?

5. A commuting student leaves home and drives to school at an average speed of $40\ km/h$. After 24 minutes he realizes that he has forgotten his homework and returns home to get it at the same average speed. It takes 10 minutes to find the report, after which the trip to school $40\ km$ away to the east is resumed at the same speed as before. (a) What is the average speed for the entire trip? (b) What is the average velocity for the entire trip?

6. A Nissan Sentra can accelerate from 0 to $48\ km/h$ in $3.6\ s$ and from 0 to $96\ km/h$ in $10.2\ s$. In addition, under constant acceleration from rest it crosses the $0.40\ km$ marker at a speed of $130\ km/h$. (a) Calculate the average acceleration needed to reach $48\ km/h$. (b) Calculate the average acceleration during the time it takes to go from $48\ km/h$ to $96\ km/h$. (c) What constant acceleration would be required to reach a speed of $130\ km/h$ over the $0.40\ km$ course when starting from rest?

7. A motorcycle traveling with a constant acceleration of $2.00\ m/s^2$ crosses a $100\ m$ long bridge in $4.23\ s$. (a) What was the velocity at the beginning of the bridge? (b) What was the velocity at the end of the bridge?

8. A Lufthansa A320 accelerates from rest to liftoff speed of $73.7\ m/s$ in $27.1\ s$. Each of the plane's two jet engines provides a forward force (thrust) of $111\ kN$. (a) What is the mass of the plane? (b) How far does the plane travel down the runway before liftoff?

9. A boat is traveling in a river with a current of $3.0\ km/h$. The boat is capable of traveling at $10.0\ km/h$ in still water. (a) How long will it take the boat to travel $7.0\ km$ upstream? (b) How long will it take to travel $7.0\ km$ downstream?

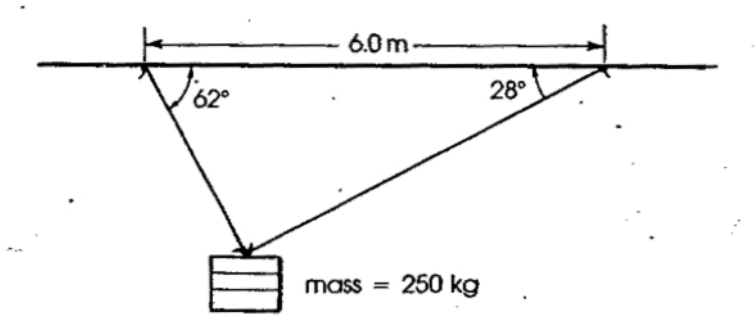
10. A small airplane flies with a speed relative to the ground (ground speed) of $208\ km/h$ in a direction $18°\ E\ of\ N$. If the plane is headed due north and the deviation from that direction is due to a crosswind blowing from west to east, what is the speed of the wind?

11. A small airplane has a cruising speed of $260\ km/h$ in still air. The pilot heads the plane in an easterly direction on a day when the wind is blowing at $25\ km/h$ in a direction $60°\ N\ of\ E$. In what direction will the plane move and what will be its ground speed?

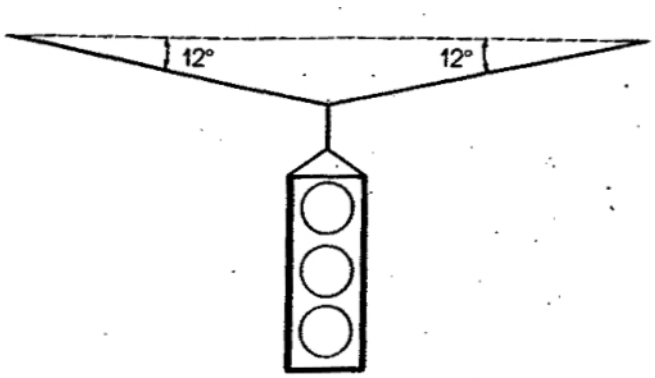
12. A boat capable of making $9.0\ km/h$ in still water is used to cross a river flowing at a speed of $4.0\ km/h$. (a) At what angle must the boat be directed so that its motion will be straight across the river? (b) What is its resultant speed relative to the shore?

13. A glass cube rests on a glass incline making an angle θ with the horizontal. The coefficient of friction between the cube and the incline is 0.92. Find the maximum angle θ for the cube to remain at rest.

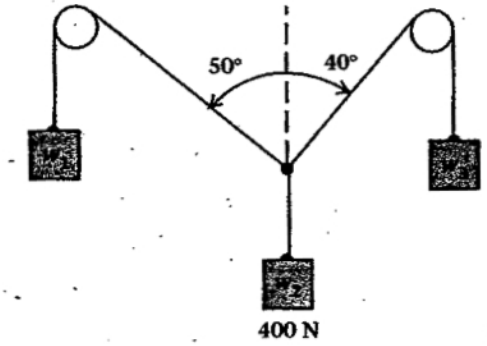
14. A load of $250\ kg$ is supported by two steel cables, as shown below. Find the tensions in the cables.



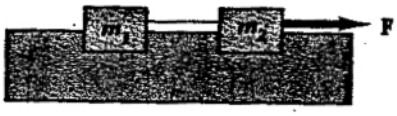
15. A $50\ kg$ traffic light is suspended above an intersection by two steel cables, as shown below. Determine the tension in the cables.



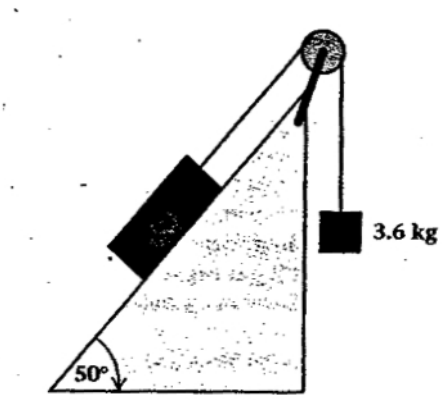
16. Suppose that the weight w_2 in the diagram below is $400\ N$. What must be the values of the weights w_1 and w_3 so that the entire system remains in equilibrium?



17. Two air-track gliders m_1 and m_2 are joined together with a light string as shown below. A constant horizontal force of $4.0\ N$ to the right is applied to mass m_2. (a) If $m_1 = 1.5\ kg$ and $m_2 = 0.50\ kg$, what is the acceleration of the gliders? (b) What is the tension in the cord joining them?

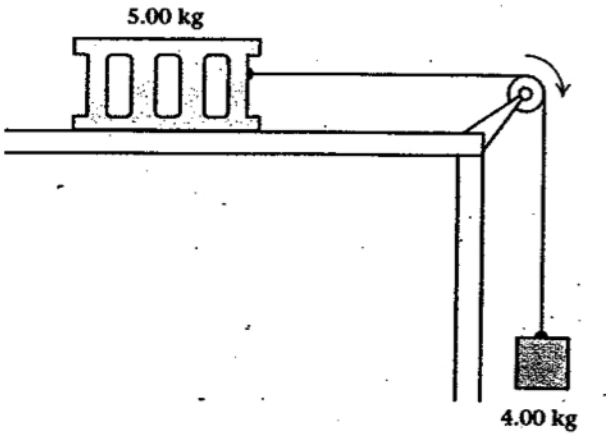


18. An $8.0\ kg$ mass rests on an inclined frictionless surface as shown below. A light string runs parallel to the surface from the mass over a light, frictionless pulley to a $3.6\ kg$ mass. Find (a) the acceleration of the masses and (b) the tension in the string.



19. A $9.75\ kg$ lead brick rests on a level wooden table. If a force of $46.4\ N$ is required to slide the brick across the table at a constant speed, what is the coefficient of friction?

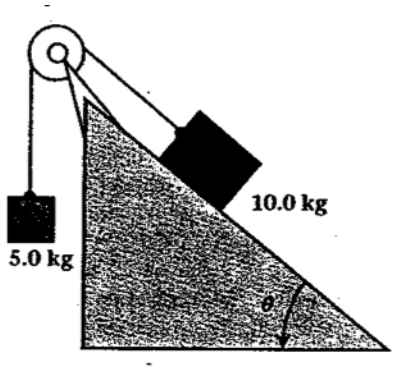
20. A $5.00\ kg$ concrete block rests on a level table. The coefficient of friction between the block and the table is 0.55. A $4.00\ kg$ weight is attached to the block by a string of negligible mass passed over a light, frictionless pulley as shown below. What is the acceleration of the block when the $4.00\ kg$ weight is released?



21. A $5.00\ kg$ concrete block rests on a level table. The coefficient of friction between the block and the table is 0.55. A $4.00\ kg$ weight is attached to the block by a string of negligible mass passed over a light, frictionless pulley as shown above. If the acceleration of the block is measured to be $1.00\ m/s^2$, what is the coefficient of friction between the block and the table?

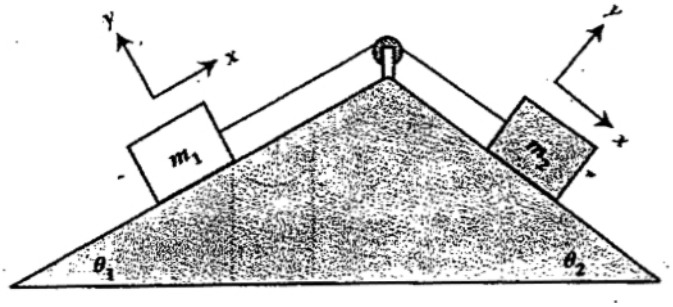
22. A crate starts from rest and slides $8.35\ m$ down a ramp. When it reaches the bottom it is traveling at a speed of $5.25\ m/s$. If the ramp makes an angle of $20°$ with the horizontal, what is the coefficient of friction between the crate and the ramp?

23. A $10.0\ kg$ block is placed on a frictionless inclined plane and connected to a $5.0\ kg$ block as shown below. (a) What would the angle θ have to be for the blocks to remain motionless? (b) What would be the acceleration of the blocks if $\theta = 37°$?

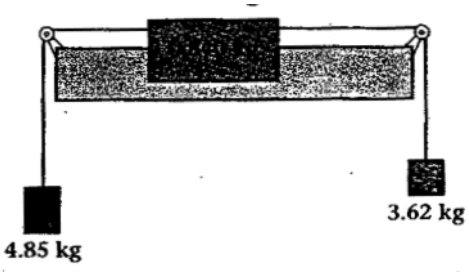


24. What minimum force is required to drag a carton of books across the floor at constant speed if the force is applied at an angle of $45°$ to the horizontal? Take the mass of the carton as $40\ kg$ and the coefficient of friction as 0.60.

25. Two blocks are connected by a light string passing over a pulley as shown below. The inclined surfaces are frictionless and the effects of the pulley can be ignored. If the values are mass $m_2 = m_1 = 1.00\ kg$, $\theta_1 = 46°$, and $\theta_2 = 34°$, what is the acceleration of the blocks?



26. A $0.840\ kg$ glider on a level air track is joined by strings to two hanging masses as shown below. The strings have negligible mass and pass over light, frictionless pulleys. (a) Find the acceleration of the masses and (b) the tension in the strings when the air flow is turned off and the coefficient of friction between the glider and the track is 0.47.



27. A $0.145\ kg$ baseball is pitched at $42\ m/s$. The batter hits it horizontally to the pitcher at $58\ m/s$.

    a) Find the change in momentum of the ball.

    b) If the ball and bat were in contact $4.6\times10^{-4}\ s$, what would be the average force while they touched?

28. A $550\ kg$ car traveling at $24.0\ m/s$ collides head-on with a $680\ kg$ pickup truck. Both vehicles come to a complete stop upon impact.

    a) What is the momentum of the car before the collision?

    b) What is the change in momentum of the car?

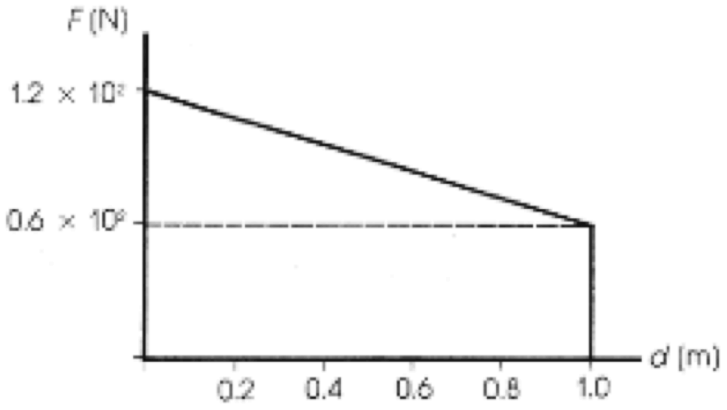
    c) What is the change in momentum of the truck?

    d) What is the velocity of the truck before the collision?

29. A $50.0\ g$ projectile is launched with a horizontal velocity of $647\ m/s$ from a $4.65\ kg$ launcher moving in the same direction at $2.0\ m/s$. What is the velocity of the launcher after the projectile is launched?
30. Two lab carts are pushed together with a spring mechanism compressed between them. Upon release, the $5.0\ kg$ cart repels one way with a velocity of $0.12\ m/s$ while the $2.0\ kg$ cart goes in the opposite direction. What velocity does it have?

31. A $12.0\ g$ rubber bullet travels at a velocity of $150\ m/s$, hits a stationary $8.5\ kg$ concrete block resting on a frictionless surface, and ricochets in the opposite direction with a velocity of $-100\ m/s$. How fast will the concrete block be moving?

32. A pellet of mass $5.0\ g$ is fired from a heavy gun whose barrel is $100\ cm$ long. The force on the pellet while it is in the barrel is given by the graph below. What is the velocity of the pellet as it leaves the barrel?



33. A cannonball is dropped from the top of a building. If the point of release is $32.0\ m$ above the ground, what is the speed of the cannonball just before it strikes the ground?

34. A ball is thrown straight up so that it reaches a height of $25\ m$. How fast was it going when it was $5\ m$ high?

35. A cougar leaps horizontally from the top of a cliff with an initial velocity of $8.25\ m/s$. The cliff is $6.43\ m$ tall. (a) Sketch the path of the cougar. (b) What are the magnitude and the direction of the velocity when the cougar is halfway to the ground?

36. A ball thrown horizontally from a $13\ m$ high building strikes the ground $5.0\ m$ from the building. With what velocity was the ball thrown?

37. A ball is thrown upward from a platform $5.2\ m$ high with a speed of $15\ m/s$ at an angle of $40°$ from the horizontal. What is the magnitude of its velocity when it hits the ground?

38. What is the centripetal acceleration of an automobile driving at $40\ km/h$ on a circular track of radius $20\ m$?

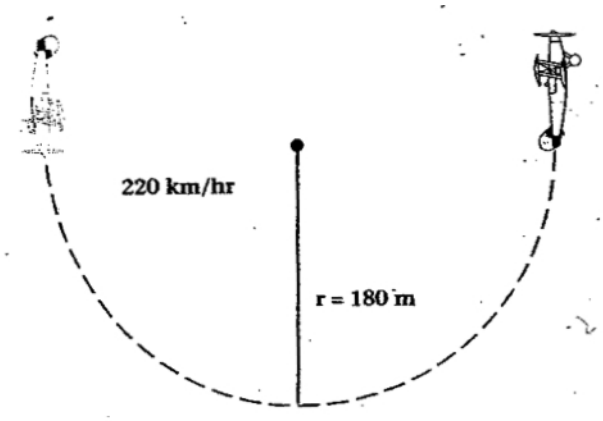
39. Jupiter's moon Europa has an average orbital radius of $6.67\times10^{8}\ m$ and a period of $85.2\ h$. Calculate the magnitude of (a) its average orbital speed, and (b) the centripetal acceleration of Europa.

40. Calculate the centripetal force on a $2000\ kg$ automobile rounding a curve of $175\ m$ radius at a speed of $50\ km/h$.

41. An electron with mass $9.11\times10^{-31}\ kg$ moves with a speed of $2.00\times10^{6}\ m/s$ in a circle of $2.85\ cm$ radius under the influence of a magnetic field. A proton of mass $1.67\times10^{-27}\ kg$,

moving in the same plane with the same speed, experiences the same centripetal force. What is the radius of the proton's orbit?

42. A stunt pilot in an airplane diving vertically downward at a speed of $220\ km/h$ turns vertically upward by following an approximately semicircular path with a radius of $180\ m$ as shown below. (a) How many g's does the pilot experience due to his motion alone? (b) By what factor does the pilot's weight appear to increase at the bottom of the dive?



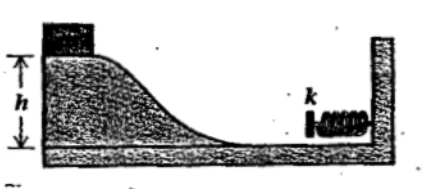
43. What is the maximum speed with which a $1000\ kg$ car can round a turn of radius $85\ m$ on a flat road if the coefficient of friction between tires and road is 0.60? Is this result independent of the mass of the car?

44. A $50\ kg$ sled is pulled $20\ m$ over the ice at a constant speed. The coefficient of friction between sled and ice is 0.13. (a) What is the frictional force? (b) how much work is done in pulling the sled the $20\ m$?

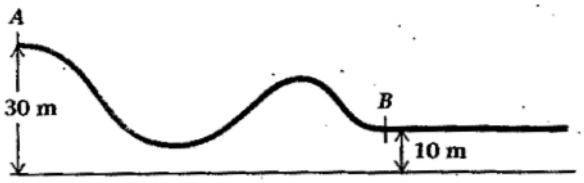
45. (a) How much work is needed to push a $132\ kg$ packing crate a distance of $2.65\ m$ up a frictionless inclined plane that makes an angle of $20°$ with the horizontal? (b) How much work would be required to move the crate the same distance if the coefficient of friction were 0.20?

46. (a) How much work is required to increase the speed of a $1200\ kg$ automobile from $10\ km/h$ to $30\ km/h$? (b) How much work is required to further increase the speed by the same amount, this time from $30\ km/h$ to $50\ km/h$? Neglect the effects of friction.

47. A block of mass $m = 1250\ g$ is released from rest and slides down a frictionless track of height $h = 45.2\ cm$. At the bottom of the track the block slides freely along a horizontal table until it hits a spring attached to a heavy, immovable wall as shown below. The spring compressed by $3.24\ cm$ at the maximum compression. What is the value of the spring constant k?



48. A $500\ kg$ roller coaster starts from rest at point A and rolls freely (no friction) to point B where the brakes are applied and it slides along horizontally with a frictional force of $440\ N$. How far does the coaster slide past point B before coming to rest?



49. A stone thrown downward with a speed of $15.7\ m/s$ from a height of $12.7\ m$ above the ground has a kinetic energy of $293\ J$ when it is $1.29\ m$ above the ground. What is the mass of the stone?

50. A $40\ kg$ child sits in a swing suspended with $2.5\ m$ long ropes. The swing is held aside so that the ropes make an angle of $15°$ with the vertical. Use conservation of energy to determine the speed the child will have at the bottom of the arc when she is let go.