Physics

Solutions to Sample Exam 1

	a.	b.	c.	d.
1.	X			
2.	X			
3.		X		
4.		X		
5.		X		
6.				X
7.		X		
8.	X			
9.				X
10.				X
11.			X	
12.		X		
13.		X		
14.	X			
15.	X			
16.		X		
17.				X
18.	X			
19.			X	
20.		X		
21.				X
22.		X		
23.		X		

	a.	b.	c.	d.
24.		X		
25.	X			
26.				X
27.			X	
28.				X
29.		X		X
30.	X			
31.		X		
32.	X			
33.			X	
34.	X			
35.				X
36.		X		
37.	X			
38.	X			
39.			X	
40.	X			
41.			X	
42.				X
43.		X		
44.		X		
45.			X	

1. **Problem**
A runner completes a marathon $(42.195\,\mathrm{km})$ with an average pace of $3\,\mathrm{minutes}$ and $4\,\mathrm{seconds}$ per $\mathrm{kilometre}$. What is the runner's time for the marathon? (Answers are formatted as $\mathrm{hours} : \mathrm{minutes} : \mathrm{seconds}$)

   a. $02 : 09 : 24$
   b. $03 : 07 : 32$
   c. $02 : 22 : 27$
   d. $03 : 10 : 31$

Solution
First, calculate the speed in kilometres per second.

$$v = \frac{1\,\mathrm{km}}{180\,\mathrm{s} + 4\,\mathrm{s}} = 0.005\,434\,8\,\mathrm{km/s}$$

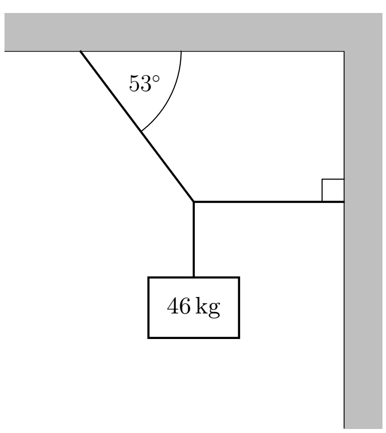
Then, calculate the time using the formula for constant velocity motion.

$$t = \frac{d}{v} = \frac{42.195\,\mathrm{km}}{0.005\,434\,8\,\mathrm{km/s}} = 7764\,\mathrm{s}$$

Finally, convert the number of seconds into hours, minutes, and seconds. $(60\,\mathrm{s}$ = $1\,\mathrm{minute}$ and $60\,\mathrm{minutes}$ = $1\,\mathrm{hour})$

$$7764\,\mathrm{s} = 2\,\mathrm{hours}, 9\,\mathrm{minutes}, 24\,\mathrm{seconds}$$

2. **Problem**
A box of mass $46\,\mathrm{kg}$ hangs down from three attached cords secured to the ceiling and wall as shown in the diagram. Find the maximum tension in any one of the three cords.



   a. $564\,\mathrm{N}$
   b. $451\,\mathrm{N}$
   c. $798\,\mathrm{N}$
   d. $704\,\mathrm{N}$

Solution
The vertical cord can only apply a vertical force and the horizontal cord can only apply a horizontal cord. However, the angled cord must oppose both the vertical force and the horizontal forces from the other two cords. Therefore, the maximum tension is found in the angled cord.

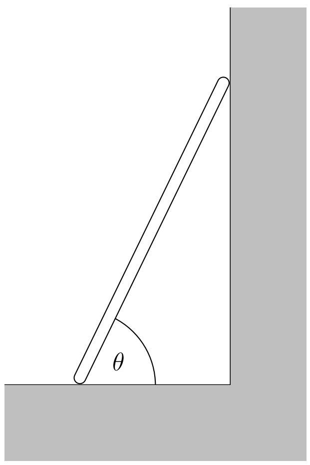
Let T be the tension in the angled cord. The vertical component of this tension, T_y, must be equal to the weight of the box, mg.

$$T_y = T \sin\theta = mg$$

Solving for T:

$$T = \frac{mg}{\sin\theta} = \frac{(46\,\mathrm{kg})(9.8\,\mathrm{N/kg})}{\sin(53°)} = 564\,\mathrm{N}$$

3. **Problem**
   A uniform ladder of mass $6\,\mathrm{kg}$ and length $3\,\mathrm{m}$ leans against a frictionless wall. Let θ be the angle that the ladder makes with the ground. If the coefficient of static friction between the ladder and the ground is 0.53, what is the minimum value of θ at which the ladder will not slip?



   a. $28°$
   b. $43°$
   c. $32°$
   d. $57°$

   Solution
   Let F_G be the force from the ground, F_f be the force of friction that the ground exerts on the bottom of the ladder, and $\mu = 0.53$ be the coefficient of static friction between the ladder and the ground.

   The horizontal component of F_G comes from the friction between the ladder and the ground:

$$F_f = F_{G,x}$$

   The vertical component of F_G is the normal force used to calculate the friction force. It is also the only force that balances the vertical gravitational force on the ladder:

$$F_f = \mu F_{normal} = \mu F_{G,y} = \mu mg$$

   Therefore, combining the two equations, we have:

$$F_{G,x} = \mu mg$$

   To find the values of $F_{G,y}$, we need to consider the net torque about the axis passing through the bottom of the ladder. Let the weight of the ladder be mg, the force from the wall be F_W, and the length of the ladder be d.

$$\tau_{net} = dF_W \sin\theta - \frac{d}{2}mg\cos\theta = 0$$

Solving for F_W, we get:

$$F_W = \frac{mg\cos\theta}{2\sin\theta}$$

Notice that as θ decreases, F_W increases and the corresponding friction force has to increase as well to keep the ladder from slipping. Since the only horizontal forces are from the ground and the wall, we must have

$$F_W = F_{G,x} = \mu mg = \frac{mg\cos\theta}{2\sin\theta}$$

Some algebra to rearrange the equation so that we can solve for θ:

$$\frac{1}{2\mu} = \frac{\sin\theta}{\cos\theta} = \tan\theta$$

$$\theta = \tan^{-1}\left(\frac{1}{2\mu}\right) = \tan^{-1}\left(\frac{1}{1.06}\right) = 43^\circ$$

4. **Problem**
   A person weighing $675\,\mathrm{N}$ stands with one foot on each of two bathroom scales. Which statement is correct about this situation?

   a. Each scale should read $337.5\,\mathrm{N}$
   b. The sum of the two scale readings should be $675\,\mathrm{N}$
   c. None of the other statements are true.
   d. Each scale should read $675\,\mathrm{N}$

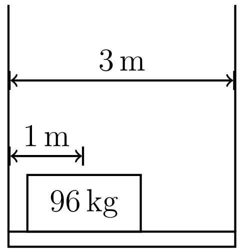
   Solution
   Since the person is at rest, the net force on the person must be zero. The normal force on the person from the two scales must cancel out the person's weight. Therefore, the sum of the two scale readings should be equal to the person's weight.

5. **Problem**
   A rocket moves through outer space with a constant velocity of $9.8\,\mathrm{m/s}$ toward the Andromeda galaxy. What is the net force acting on the rocket?

   a. Cannot be determined without more information.
   b. The net force is zero.
   c. A force equal to its weight on Earth, mg.
   d. A force equal to the gravity acting on it.

   Solution
   Since the rocket is moving with constant velocity, its acceleration is zero and the net force acting on the rocket must also be zero.

6. **Problem**
   A scaffold of negligible mass is hanging horizontally from wires on each end. The scaffold is $3\,\mathrm{m}$ long. A $96\,\mathrm{kg}$ box sits $1\,\mathrm{m}$ from the left end. What is the tension in each wire?



a. left tension = $64\,\mathrm{N}$; right tension = $32\,\mathrm{N}$
b. left tension = $314\,\mathrm{N}$; right tension = $627\,\mathrm{N}$
c. left tension = $470\,\mathrm{N}$; right tension = $470\,\mathrm{N}$
d. left tension = $627\,\mathrm{N}$; right tension = $314\,\mathrm{N}$

Solution
The net force on the scaffold must be zero. Let T_1 be the tension in the left wire and T_2 be the tension in the right wire:

$$T_1 + T_2 - mg = 0$$

The net torque about the axis going through the point in the platform right below the centre of the box must also be zero. We choose this axis to eliminate the torque from the weight of the box. Let $d_1 = 1\,\mathrm{m}$ and $d_2 = 2\,\mathrm{m}$:

$$T_1 d_1 - T_2 d_2 = 0$$

Solving the above system of linear equations by elimination or substitution gives:

$$T_1 = \left(\frac{d_2}{d_1 + d_2}\right) mg = \left(\frac{2}{3}\right)(96\,\mathrm{kg})(9.8\,\mathrm{N/kg}) = 627\,\mathrm{N}$$

$$T_2 = \left(\frac{d_1}{d_1 + d_2}\right) mg = \left(\frac{1}{3}\right)(96\,\mathrm{kg})(9.8\,\mathrm{N/kg}) = 314\,\mathrm{N}$$

7. **Problem**
A car traveling at speed v is able to stop in a distance d. Assuming the same constant acceleration, what distance does this car require to stop when it is traveling at speed $8v$?

a. $8d$
b. $64d$
c. d
d. $\sqrt{8}d$

Solution
Solve $v_f^2 = v_i^2 + 2ad$ for d and set $v_f = 0$ to get

$$d = -\frac{v_i^2}{2a}$$

Therefore, the braking distance is proportional to the square of the initial velocity. If the initial velocity is multiplied by 8, then the car would need 8^2 times the distance to stop.

8. **Problem**
True or false? It is possible to have zero acceleration and still be moving.

a. True
b. False

Solution
True. An object with a constant nonzero velocity has zero acceleration and is still moving.

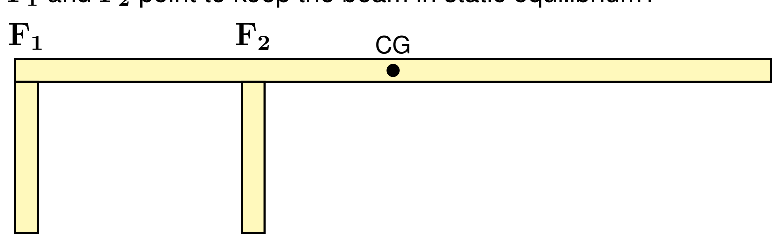
9. **Problem**
A boy and a girl are balanced on a massless seesaw. The boy's mass is $64\,\mathrm{kg}$ and the girl's mass is $45\,\mathrm{kg}$. If the boy is sitting $2.9\,\mathrm{m}$ from the pivot, how far from the pivot must the girl be sitting on the other side of the seesaw?

a. $2.7\,\mathrm{m}$
b. $2.4\,\mathrm{m}$
c. $3.1\,\mathrm{m}$
d. $4.1\,\mathrm{m}$

Solution
Since the torque on the seesaw is balanced, we must have $m_b d_b = m_g d_g$ where m_b is the mass of the boy, d_b is the distance of the boy from the pivot, and m_g and d_g are corresponding quantities for the girl. Solving for d_g gives:

$$d_g = \left(\frac{m_b}{m_g}\right) d_b = \left(\frac{64\,\mathrm{kg}}{45\,\mathrm{kg}}\right) 2.9\,\mathrm{m} = 4.1\,\mathrm{m}$$

10. **Problem**
A cantilever is held in static equilibrium by two vertical supports as shown in the figure. The beam is fastened to the supports with screws so that each support could apply an upward or downward force. The centre of gravity (CG) of the beam is to the right of the second support. In which direction must $\mathbf{F_1}$ and $\mathbf{F_2}$ point to keep the beam in static equilibrium?



a. $\mathbf{F_1}$ and $\mathbf{F_2}$ both point upward
b. $\mathbf{F_1}$ and $\mathbf{F_2}$ both point downward
c. $\mathbf{F_1}$ points upward while $\mathbf{F_2}$ points downward
d. $\mathbf{F_1}$ points downward while $\mathbf{F_2}$ points upward

Solution
The net force and the net torque (around any axis) on the beam must be zero in order for the beam to be in static equilibrium.

In order to oppose the downward force of gravity on the beam, the vector sum of $\mathbf{F_1}$ and $\mathbf{F_2}$ must point upward. Then, considering the torque about the centre of gravity of the beam, $\mathbf{F_1}$ and $\mathbf{F_2}$ must point in opposite directions and $\mathbf{F_2}$ must be greater than $\mathbf{F_1}$ for the torques to cancel out (since $\mathbf{F_2}$ is closer to the axis). Therefore, $\mathbf{F_2}$ must point up and $\mathbf{F_1}$ must point down.

11. **Problem**
The acceleration of gravity on the Moon is one-sixth of that on Earth. If you hit a baseball on the Moon with the same speed and angle that you would on Earth, the ball would land

   a. the same distance away
   b. one-sixth as far
   c. 6 times as far
   d. 36 times as far

Solution
The air time of the ball can be calculated from the formula $v_f = v_i + at$ with $v_f = -v_i$.

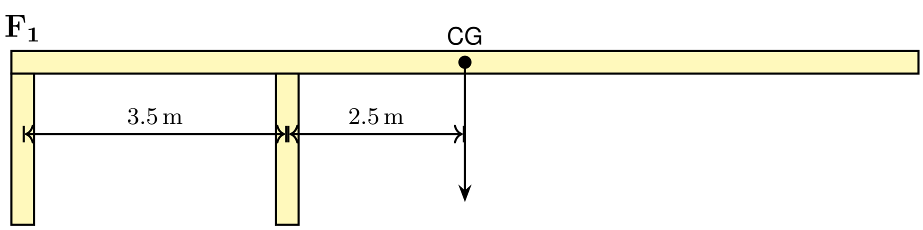
$$t = -\frac{2v_i}{a}$$

On Earth, the time is $t_{Earth} = -2v_i/g_{Earth}$. On the Moon, $g_{Moon} = g_{Earth}/6$ so

$$t_{Moon} = -\frac{2v_i}{g_{Earth}/6} = 6 \times \frac{-2v_i}{g_{Earth}} = 6t_{Earth}$$

The air time of the ball is 6 times greater on the Moon than on Earth. Since the horizontal velocity is the same, the ball will travel six times as far.

12. **Problem**
A cantilever beam is held in static equilibrium by two vertical supports separated by $3.5\,\mathrm{m}$. The beam's mass is $69\,\mathrm{kg}$ and its centre of gravity (CG) is $2.5\,\mathrm{m}$ from the second support. What is the magnitude of the force applied by the first support, $\mathbf{F_1}$?



   a. $570\,\mathrm{N}$
   b. $480\,\mathrm{N}$
   c. $970\,\mathrm{N}$
   d. $48\,\mathrm{N}$

Solution
The net force on the beam must be zero. Assuming that F_1 points down and F_2 points up:

$$-F_1 + F_2 - mg = 0$$

The net torque about the centre of gravity (CG) must be zero. Let $d_1 = 6\,\mathrm{m}$ be the distance from the CG to the first support and $d_2 = 2.5\,\mathrm{m}$ be the distance from the CG to the second support:

$$d_1F_1 - d_2F_2 = 0$$

Solving the above system of linear equations for F_1 (by substitution or elimination) gives:

$$F_1 = \left(\frac{d_2}{d_1 - d_2}\right) mg = \left(\frac{2.5}{6 - 2.5}\right) (69\,\mathrm{kg})(9.8\,\mathrm{N/kg}) = 480\,\mathrm{N}$$

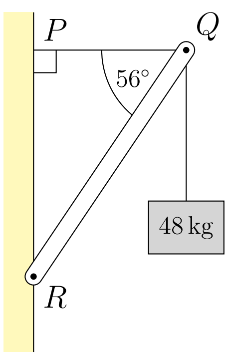
13. **Problem**
Suppose an object travels at a constant velocity of $5.18\,\mathrm{m/s}$. How much time would it take for the object to travel a distance of $60.1\,\mathrm{m}$?

   a. $0.09\,\mathrm{s}$
   b. $11.6\,\mathrm{s}$
   c. $227\,\mathrm{s}$
   d. $311\,\mathrm{s}$

Solution
Use the formula for constant velocity motion.

$$t = \frac{d}{v} = \frac{60.1\,\mathrm{m}}{5.18\,\mathrm{m/s}} = 11.6\,\mathrm{s}$$

14. **Problem**
A uniform beam QR, $1.0\,\mathrm{m}$ long with negligible mass, is mounted by a hinge on a wall and held in position by a horizontal wire PQ as shown in the figure. The beam supports a load of mass $48\,\mathrm{kg}$ hanging vertically down from point Q. What is the magnitude of the force on the hinge at point R?



   a. $567\,\mathrm{N}$
   b. $522\,\mathrm{N}$
   c. $130\,\mathrm{N}$
   d. $164\,\mathrm{N}$

Solution
Since the mass of the beam is negligible, only two forces apply a torque on the beam about the hinge point R: the tension in the horizontal wire, T_{PQ}, and the force from the hanging load, mg.

To calculate the torque from these two forces, we need to calculate the component of the force that is perpendicular to the beam. For the horizontal wire, this means multiplying by $\sin(56°)$ while for the vertical wire, this means multiplying by $\cos(56°)$.

The net torque must be zero since the beam is in static equilibrium. Let r be the length of the beam. Then, the equation for the net torque is:

$$\tau_{net} = rT_{PQ}\sin(56°) - rmg\cos(56°) = 0$$

The factors of r cancel out (so the length of $2.0\,\mathrm{m}$ was not needed). Solving for T_{PQ}, we get

$$T_{PQ} = \frac{mg\cos(\theta)}{\sin(\theta)}$$

To keep the beam in static equilibrium, the net force must also be zero. This means that the force on the hinge must be equal to the sum of the forces applied by the tension in the wire and the hanging mass. Since the two forces are perpendicular, we can use the Pythagorean theorem to calculate the magnitude of their sum.

$$F_{hinge} = \sqrt{(mg)^2 + (mg)^2\frac{\cos^2(\theta)}{\sin^2(\theta)}} = mg\sqrt{1 + \frac{\cos^2(\theta)}{\sin^2(\theta)}} = mg\sqrt{\frac{\sin^2(\theta)}{\sin^2(\theta)} + \frac{\cos^2(\theta)}{\sin^2(\theta)}}$$

Using the Pythagorean identity ($\sin^2\theta + \cos^2\theta = 1$), we can simplify further:

$$F_{hinge} = mg\sqrt{\frac{\sin^2(\theta) + \cos^2(\theta)}{\sin^2(\theta)}} = mg\sqrt{\frac{1}{\sin^2(\theta)}} = \frac{mg}{\sin(\theta)}$$

Plugging in the numbers from the problem, we get:

$$F_{hinge} = \frac{(48\,\mathrm{kg})(9.8\,\mathrm{m/s^2})}{\sin(56°)} = 567\,\mathrm{N}$$

15. **Problem**
What is the magnitude of the average velocity of a runner who completes one lap around an outdoor track ($400\,\mathrm{m}$) in $100\,\mathrm{s}$?

    a. $0\,\mathrm{m/s}$
    b. $0.25\,\mathrm{m/s}$
    c. $4.0\,\mathrm{m/s}$
    d. $4.0 \times 10^4\,\mathrm{m/s}$

    Solution
The average velocity is a vector quantity defined as the total displacement divided by the time interval. Since the runner returns to their starting position after running one lap, the total displacement is zero and the average velocity is also zero.

16. **Problem**
An F1 car accelerates from 0 to 60 miles per hour in $2.17\,\mathrm{s}$. What is the acceleration of the car in SI base units? ($1\,\mathrm{mile} = 1609.34\,\mathrm{m}$)

    a. $13.8\,\mathrm{m/s^2}$
    b. $12.4\,\mathrm{m/s^2}$
    c. $19.9\,\mathrm{m/s^2}$
    d. $27.6\,\mathrm{m/s^2}$

    Solution
First, convert $60\,\mathrm{mph}$ to $\mathrm{m/s}$.

$$60\,\mathrm{mph} \times \frac{1609.34\,\mathrm{m}}{1\,\mathrm{mi}} \times \frac{1\,\mathrm{h}}{3600\,\mathrm{s}} = 26.8223\,\mathrm{m/s}$$

Then, divide by the time.

$$a = \frac{v_f - v_i}{t} = \frac{26.8223\,\mathrm{m/s} - 0}{2.17\,\mathrm{s}} = 12.4\,\mathrm{m/s^2}$$

17. **Problem**
A $5\,\mathrm{kg}$ ball and a $10\,\mathrm{kg}$ ball are both dropped off a cliff at the same time. If air drag can be ignored, then the $10\,\mathrm{kg}$ ball falls

    a. $50\,\%$ faster than the $5\,\mathrm{kg}$ ball.
    b. with double the velocity of the $5\,\mathrm{kg}$ ball.
    c. with double the acceleration of the $5\,\mathrm{kg}$ ball.
    d. with the same acceleration as the $5\,\mathrm{kg}$ ball.

    Solution
    The acceleration due to gravity on the surface of the Earth does not depend on the object's mass. All objects in free fall move with the same acceleration if air drag can be ignored.

18. **Problem**
What is the maximum height reached by a ball thrown straight up with an initial velocity of $39.9\,\mathrm{m/s}$? Assume that the ball is thrown on the surface of the Earth and that it undergoes constant acceleration due to gravity (ignore air resistance).

    a. $81.2\,\mathrm{m}$
    b. $143.1\,\mathrm{m}$
    c. $72.4\,\mathrm{m}$
    d. $73.6\,\mathrm{m}$

    Solution
    Use the formula $v_f^2 = v_i^2 + 2ad$ with $a = g = -9.8\,\mathrm{m/s^2}$ and $v_f = 0$ (the velocity of the ball at its maximum height is zero). Solve for d:

$$d = \frac{-v_i}{2a} = \frac{-39.9\,\mathrm{m/s}}{2(-9.8\,\mathrm{m/s^2})} = 81.2\,\mathrm{m}$$

19. **Problem**
Can an object's velocity change direction when its acceleration is constant?

    a. No, because the object is always speeding up.
    b. No, because the object is always speeding up or slowing down, but it can never turn around.
    c. Yes, a rock thrown straight up is an example.
    d. Yes, a car that starts from rest, speeds up, slows to a stop, and then backs up is an example.

    Solution
    Yes, a rock thrown straight up is an example. The direction of the rock's velocity changes from up to down while its acceleration is always $9.8\,\mathrm{m/s^2}$ down.

20. **Problem**
True or false? When you throw a ball to your friend, the ball's acceleration is zero when it reaches its maximum height.

   a. True
   b. False

Solution
False. The acceleration of the ball is always $9.8\,\mathrm{m/s^2}$ down.

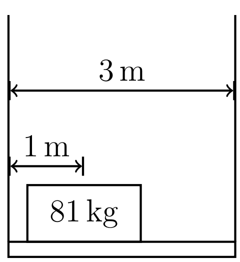
21. **Problem**
Which of the following is a scalar quantity?

   a. acceleration
   b. velocity
   c. displacement
   d. speed

Solution
A scalar quantity is fully described by magnitude only. A vector quantity is fully described by both magnitude and direction. Distance, speed, and time are scalars. Acceleration, displacement, and velocity are vectors.

   a. vector
   b. vector
   c. vector
   d. scalar

22. **Problem**
A scaffold of negligible mass is hanging horizontally from wires on each end. The scaffold is $3\,\mathrm{m}$ long. A $81\,\mathrm{kg}$ box sits $1\,\mathrm{m}$ from the left end. What is the tension in the left wire?



   a. $212\,\mathrm{N}$
   b. $529\,\mathrm{N}$
   c. $253\,\mathrm{N}$
   d. $159\,\mathrm{N}$

Solution
To avoid needing to know the tension in the right wire, we can calculate the torque about the rotation axis going through the right side of the scaffold. Let T_1 be the tension in the left wire, $d_B = 2\,\mathrm{m}$, and $d_L = 3\,\mathrm{m}$. Then,

$$T_1 d_L = mgd_B$$

Solving for T_1:

$$T_1 = \left(\frac{d_B}{d_L}\right) mg = \left(\frac{2}{3}\right)(81\,\mathrm{kg})(9.8\,\mathrm{N/kg}) = 529\,\mathrm{N}$$

23. **Problem**
Ball 1 is dropped from the top of a building. One second later, ball 2 is dropped from the same building. If air resistance can be ignored, then as time progresses (and while the balls are still in free fall), the difference in their speeds

    a. increases.
    b. remains constant.
    c. decreases.
    d. cannot be determined from the given information.

    Solution
    Since both balls are accelerating at the same rate, the difference in their velocities will remain constant. Using the formula $v_f = v_i + at$, with $a = g$ and $v_i = 0$, we see that

$$\Delta v = v_1 - v_2 = gt_1 - gt_2 = g(t_1 - t_2)$$

and both $g = 9.8\,\mathrm{m/s^2}$ and $(t_1 - t_2) = 1$ s remain constant.

Note that if air resistance is an important factor, then the difference would change until both balls are falling at their terminal velocity.

24. **Problem**
Suppose that several projectiles are launched. Which one will be in the air for the longest time?

    a. The one with the furthest horizontal range.
    b. The one with the greatest maximum height.
    c. The one with the greatest initial speed.
    d. None of the above.

    Solution
    Since horizontal and vertical motions can be analyzed separately, only the vertical motion matters for the longest air time. The projectile with the greatest maximum height will stay up in the air for the longest time.

25. **Problem**
What is stress?

    a. The strain per unit length.
    b. The same as force.
    c. The applied force per cross-sectional area.
    d. The ratio of the change in length to the original length.

    Solution
    Strain is the ratio of the change in length to the original length.

    strain = $\frac{\Delta L}{L_0}$

26. **Problem**
Two displacement vectors have magnitudes of $5\,\mathrm{m}$ and $7\,\mathrm{m}$, respectively. When these two vectors are added, the magnitude of the sum

a. is $12\,\mathrm{m}$
b. is $2\,\mathrm{m}$
c. is larger than $12\,\mathrm{m}$
d. could be as small as $2\,\mathrm{m}$, or as large as $12\,\mathrm{m}$

Solution
If the two vectors point in the same direction, then the magnitude of their sum is $12\,\mathrm{m}$. If the two vectors point in opposite directions, then the magnitude of their sum is $2\,\mathrm{m}$. Otherwise the magnitude of their sum is somewhere between $2\,\mathrm{m}$ and $12\,\mathrm{m}$

27. **Problem**
What is the magnitude of the slope of a position-time graph?

a. displacement
b. distance
c. speed
d. rate

Solution
The magnitude of the slope of a position-time graph is the speed of the object.

28. **Problem**
A car travels $42\,\mathrm{km}$ at $32\,\mathrm{km/h}$ and $238\,\mathrm{km}$ at $114\,\mathrm{km/h}$. What is the average speed for this trip?

a. $72\,\mathrm{km/h}$
b. $59\,\mathrm{km/h}$
c. $37\,\mathrm{km/h}$
d. $82\,\mathrm{km/h}$

Solution
The average speed is the total distance divided by the total time.

$$v_{avg} = \frac{d_{total}}{t_{total}} = \frac{d_1 + d_2}{d_1/v_1 + d_2/v_2} = \frac{42\,\mathrm{km} + 238\,\mathrm{km}}{\frac{42\,\mathrm{km}}{32\,\mathrm{km/h}} + \frac{238\,\mathrm{km}}{114\,\mathrm{km/h}}} = 82\,\mathrm{km/h}$$

29. **Problem**
    Which of the following are vectors? *Select all that apply.*

    a. speed
    b. velocity
    c. time
    d. acceleration

    Solution
    A scalar quantity is fully described by magnitude only. A vector quantity is fully described by both magnitude and direction. Distance, speed, and time are scalars. Acceleration, displacement, and velocity are vectors.

    a. scalar
    b. vector
    c. scalar
    d. vector

30. **Problem**
    True or false? When a ball is thrown straight up, its velocity at the top is zero.

    a. True
    b. False

    Solution
    True. The velocity must be zero for an instant at the top as the velocity changes from up to down.

31. **Problem**
    Identify the following quantity as being either a scalar or a vector: $37\,\mathrm{N}$, right

    a. scalar
    b. vector
    c. both scalar and vector
    d. neither scalar nor vector

    Solution
    A scalar has only magnitude (a number with units). A vector has both magnitude and direction.

32. **Problem**
    An object is released from rest and falls straight down without friction. Which of the following is true concerning its motion?

    a. Its acceleration is constant.
    b. Its velocity is constant.
    c. Neither its acceleration nor its velocity is constant.
    d. Both its acceleration and its velocity are constant.

    Solution
    Only acceleration is constant for an object in free fall.

33. **Problem**
Two balls are thrown from the top of a building. One is thrown straight up while the other is thrown straight down, both with same initial speed. If air resistance can be ignored, how do their speeds compare when they hit the ground?

   a. The ball thrown up is going faster.
   b. The ball thrown down is going faster.
   c. Both balls are going the same speed.
   d. It is impossible to determine with the given information.

Solution
The ball thrown straight up will have the same speed when it returns to the initial height. Therefore, both balls will be going the same speed when they hit the ground. (The ball thrown downward would hit the ground first because it did not travel the path up and back to the initial height. However, both balls still hit the ground with the same speed.)

34. **Problem**
Which of the following is a vector quantity?

   a. displacement
   b. distance
   c. time
   d. speed

Solution
A scalar quantity is fully described by magnitude only. A vector quantity is fully described by both magnitude and direction. Distance, speed, and time are scalars. Acceleration, displacement, and velocity are vectors.

   a. vector
   b. scalar
   c. scalar
   d. scalar

35. **Problem**
An object is moving to the left and speeding up. Which choice best describes its velocity and acceleration? (Assume right is positive.)

   a. velocity is positive; acceleration is negative.
   b. velocity is negative; acceleration is positive.
   c. velocity and acceleration are both positive.
   d. velocity and acceleration are both negative.

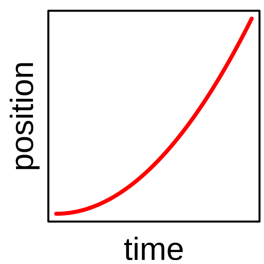
Solution
Velocity is positive if the object is moving to the right.
Velocity is negative if the object is moving to the left.
Acceleration is positive if the object is moving to the right and speeding up or moving to the left and slowing down.
Acceleration is negative if the object is moving to the right and slowing down or moving to the left and speeding up.

36. **Problem**
Consider a ball that is thrown upwards and which then falls back down. If up is the positive direction, then the ball's acceleration

 a. is always positive.
 b. is always negative.
 c. starts positive, then becomes negative.
 d. starts negative, then becomes positive.

Solution
The acceleration due to gravity is always downwards, which is the negative direction.

37. **Problem**
Which choice best matches the given position-time graph? Assume that position is increasing to the right.



 a. moving to the right and speeding up.
 b. moving to the right and slowing down.
 c. moving to the left and speeding up.
 d. moving to the left and slowing down.

Solution
The object is moving to the right if its position is increasing and moving to the left if its position is decreasing. The object is speeding up if the tangent line is becoming more vertical and slowing down if the tangent line is becoming more horizontal.

This graph describes an object that is moving to the right and speeding up.

38. **Problem**
A scalar quantity is fully described by

 a. magnitude alone
 b. direction alone
 c. both magnitude and direction
 d. none of these

Solution
A scalar quantity is fully described by magnitude alone.

39. **Problem**
A ball is thrown straight up, reaches a maximum height, then falls back down to its initial height. Which of the following is true while the ball is going up?

a. Its velocity and acceleration both point up.
b. Its velocity and acceleration both point down.
c. Its velocity points up while its acceleration points down.
d. Its velocity points down while its acceleration points up.

Solution
The velocity points up while the ball is going up. The acceleration always points down.

40. **Problem**
A heavy child and a lightweight child are balanced on a massless seesaw. If both children move forward so that they are at half of their original distance from the pivot, what will happen to the seesaw?

a. The seesaw will still be balanced.
b. The side the heavy child is sitting on will tilt downward.
c. It is impossible to determine without knowing the masses and distances.
d. The side the lightweight child is sitting on will tilt downward.

Solution
Since the seesaw is initially balanced, we must have

$$\tau_{net} = m_1 d_1 - m_2 d_2 = 0$$

Halving both distances will result in

$$\tau_{net} = m_1(d_1/2) - m_2(d_2/2) = \frac{1}{2}(m_1 d_1 - m_2 d_2) = \frac{1}{2}(0) = 0$$

Therefore, the seesaw will remain balanced.

41. **Problem**
How many seconds would it take the Sun's light to reach Earth? The speed of light in vacuum is $3.00 \times 10^8\,\mathrm{m/s}$. The Sun is $1.5 \times 10^{11}\,\mathrm{m}$ from the Earth.

a. $0\,\mathrm{s}$
b. $2.0 \times 10^{-3}\,\mathrm{s}$
c. $5.0 \times 10^{2}\,\mathrm{s}$
d. $4.5 \times 10^{19}\,\mathrm{s}$

Solution
Use the formula for constant velocity motion.

$$t = \frac{d}{v} = \frac{1.5 \times 10^{11}\,\mathrm{m}}{3 \times 10^{8}\,\mathrm{m/s}} = 5.0 \times 10^{2}\,\mathrm{s}$$

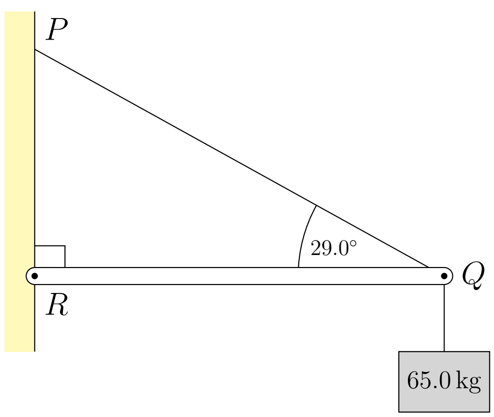
42. **Problem**
A runner completes a marathon $(42.195\,\mathrm{km})$ in $5\,\mathrm{hours}$, $17\,\mathrm{minutes}$, and $43\,\mathrm{seconds}$. What is the runner's average speed for the marathon in $\mathrm{m/s}$?

   a. $0.06\,\mathrm{m/s}$
   b. $0.61\,\mathrm{m/s}$
   c. $0.74\,\mathrm{m/s}$
   d. $2.21\,\mathrm{m/s}$

Solution
The average speed is the total distance divided by the total time.

$$d = (42.195\,\mathrm{km})(1000\,\mathrm{m/km}) = 42\,195\,\mathrm{m}$$
$$t = (5\,\mathrm{h} \times 3600\,\mathrm{s/h}) + (17\,\mathrm{min} \times 60\,\mathrm{s/min}) + 43\,\mathrm{s} = 19\,063\,\mathrm{s}$$
$$v = \frac{d}{t} = \frac{42\,195\,\mathrm{m}}{19\,063\,\mathrm{s}} = 2.21\,\mathrm{m/s}$$

43. **Problem**
A $4.0\,\mathrm{m}$ long uniform beam of mass $7.00\,\mathrm{kg}$, QR, is mounted by a hinge on a wall and held in a horizontal position by wire PQ, forming a $29.0°$ angle at point Q as shown in the figure. A load of mass $65.0\,\mathrm{kg}$ hangs vertically down from point Q. What is the magnitude of the tension in wire PQ?



   a. $2770\,\mathrm{N}$
   b. $1380\,\mathrm{N}$
   c. $564\,\mathrm{N}$
   d. $138\,\mathrm{N}$

Solution
The net torque about the hinge point R must be zero because the beam is in static equilibrium. The weight of the beam, the tension in the wire, and the hanging load each apply a torque to the beam. The force of gravity on a uniform beam can be modeled as a force, $F_g = mg$, acting on the centre of the beam. Let l be the length of the beam, θ be the angle at point Q, T be the tension in wire, m be the mass of the beam, and M be the mass of the hanging load.

$$\tau_{net} = lT\sin(\theta) - \frac{lmg}{2} - lMg = 0$$

Solving for T, we get

$$T = \frac{g}{\sin(\theta)}\left(\frac{m}{2} + M\right) = \frac{9.80\,\mathrm{N/kg}}{\sin(29.0°)}\left(\frac{7.00\,\mathrm{kg}}{2} + 65.0\,\mathrm{kg}\right) = 1380\,\mathrm{N}$$

44. **Problem**
A book weighs $8\,\mathrm{N}$ at the surface of the Earth. When held at rest on top of your head, the net force on the book is

   a. $-8\,\mathrm{N}$
   b. $0\,\mathrm{N}$
   c. $9.8\,\mathrm{N}$
   d. $8\,\mathrm{N}$

Solution
Since the book is at rest, its acceleration is zero and the net force acting on it must be zero.

45. **Problem**
Two scales are separated by $6.0\,\mathrm{m}$, and a plank of mass $6.0\,\mathrm{kg}$ is placed between them. Each scale is observed to read $3.0\,\mathrm{kg}$. A rock is placed somewhere on the plank, after which the left scale reads $50.0\,\mathrm{kg}$ and the right scale reads $80.0\,\mathrm{kg}$. How far from the left scale was the rock placed?

   a. $3.5\,\mathrm{m}$
   b. $1.6\,\mathrm{m}$
   c. $3.7\,\mathrm{m}$
   d. $1.9\,\mathrm{m}$

Solution
The first condition for static equilibrium is that the net force on the plank must be zero. This implies that the mass of the rock is the sum of the two scale readings minus the plank's mass:

$$m_{rock} = 50\,\mathrm{kg} + 80\,\mathrm{kg} - 6\,\mathrm{kg} = 124\,\mathrm{kg}$$

The second condition for static equilibrium is that the net torque on the plank must be zero. You can choose any axis to calculate the torque. Let's arbitrarily choose the left scale as the pivot. Also, let s be the separation between the two scales and x be the distance of the rock from the left scale. Then,

$$\frac{s}{2}m_{plank} + xm_{rock} - sm_{right} = 0$$

Solving for x, we get:

$$x = \frac{s}{m_{rock}}\left(m_{right} - \frac{m_{plank}}{2}\right) = \frac{6\,\mathrm{m}}{124\,\mathrm{kg}}\left(80\,\mathrm{kg} - \frac{6\,\mathrm{kg}}{2}\right) = 3.7\,\mathrm{m}$$