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Republic Polytechnic

A107 Physics

Problem Review 1 – Practice Questions

1. Convert the following:

   a) 2.5 feet = _______0.83________ yard

   b) 100 km/h = _______27.78__________ m/s

   c) 5 mm = _______5________ × 10^{-3} m

2. Given that

   1 metre = 3.281 feet
   1 yard = 3 feet

   Convert 2.5 yards to metres.
   2.5 yards = 7.5 feet = 7.5 /3.281 = 2.29 m

3. An equation is proposed as shown:

$$E = \frac{3}{5}mv$$

   where E is energy, m is the mass and v is the velocity.

   By comparing the SI base units on both sides of the equation, explain if the proposed equation is valid or not?
   On the left hand side of the equation, we know that energy is given by force × distance moved in the direction of the force; therefore base units is N·m. Since force is mass × acceleration, simplifying to the SI base units, it becomes kg·m^{2}·s^{-2}.

   On the right hand side of the equation, the units for mass is kg while for velocity is m/s. Putting it together, we have the combined base units on the right hand side of the equation as kg·m/s or kg·m·s^{-1}.

   It can be seen that the SI base units on both sides of the equation are not the same. The proposed equation is therefore not valid.

4. Determine the magnitude and direction of the net (i.e. overall) force acting on the object shown in Figure 1.

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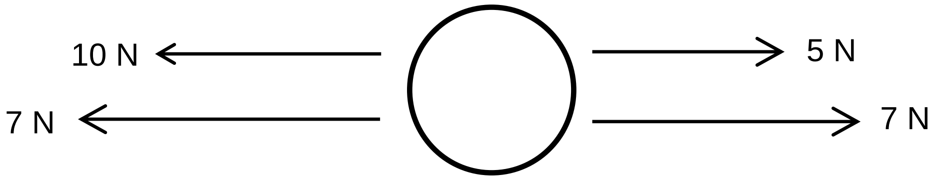

Figure 1

Net force = 17 N (to the left) − 12 N (to the right) = 5 N to the left

5. Figure 2 shows three forces acting on an object.

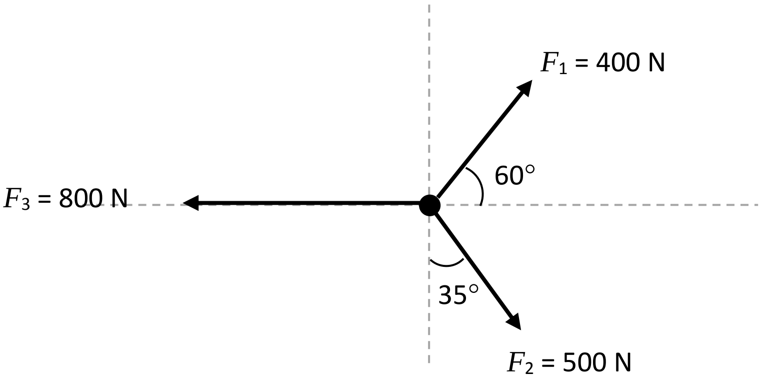

Figure 2

a) Determine the net horizontal force acting on the object.

b) Determine the net vertical force acting on the object.

c) Determine the magnitude of the net force acting on the object.

Before proceeding, let's resolve the various forces into their respective components first:

Forces	Horizontal component	Vertical Component
F_1 = 400 N	400 cos 60° = 200 N (pointing to the right)	400 sin 60° = 346.4 N (pointing upward)
F_2 = 500 N	500 cos 55° = 286.8 N (pointing to the right)	500 sin 55° = 409.6 N (pointing downward)
F_3 = 800 N	800 N to the left (given by question)	Nil.

a) Net horizontal force = 800 N – 200 N – 286.8 N
= 313.2 N (pointing to the left)

b) Net vertical force = 409.6 N – 346.4 N
= 63.2 N (pointing downward)

c) The magnitude of the net force is the net horizontal force and net vertical force combined. Using Pythagoras' theorem, magnitude of net force is thus $\sqrt{(313.2^2 + 63.2^2)} = 319.51$ N.

6. A car is initially at rest. It then accelerates with an acceleration of 12 m/s^2 for 4 s.

a) What is the velocity of the car at the end of the 4 s?

b) What is the total distance travelled by the car?

a) Using $v = u + at$, final velocity = 4 × 12 = 48 m/s since $u = 0$ m/s.

b) Using $s = ut + \frac{1}{2} at^2$, we get $s = 0 \times 4 + \frac{1}{2} \times 12 \times 4^2 = 96$ m.

7. A car is initially moving with a velocity of 10 m/s. It then accelerates with an acceleration of 8 m/s^2 for 6 s.

a) What is the final velocity of the car at the end of the 6 s?

b) What is the total distance travelled by the car in this 6 s?

a) Velocity gained = 6 × 8 = 48 m/s
Since the initial velocity is 10 m/s, together with the velocity gained of 56 m/s, the final velocity will be 10 + 48 = 58 m/s.

b) Using $s = ut + \frac{1}{2} at^2$, we get $s = 10 \times 6 + \frac{1}{2} \times 8 \times 6^2 = 204$ m.

8. Figure 3 shows the velocity-time graph of a car.

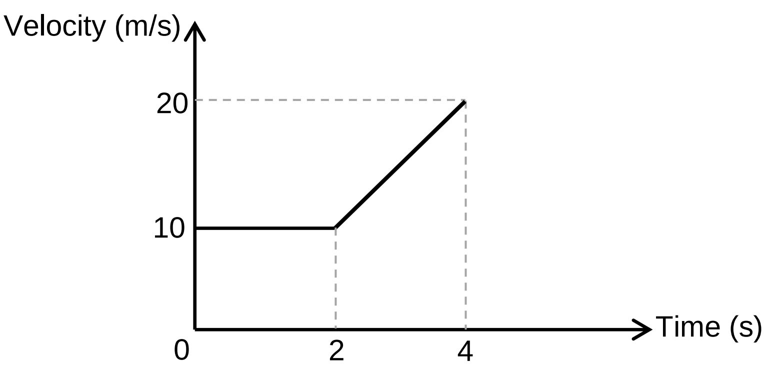

Figure 3

a) Determine the magnitude of the acceleration of the car from time $t = 0$ s to $t = 2$ s.
0 m/s^2

b) What is the total distance travelled by the car during the 4 s?
Distance travelled = (10 × 4 + ½ × 2 × 10) = 50 m

9. The velocity-time graph of a car is depicted in Figure 4.

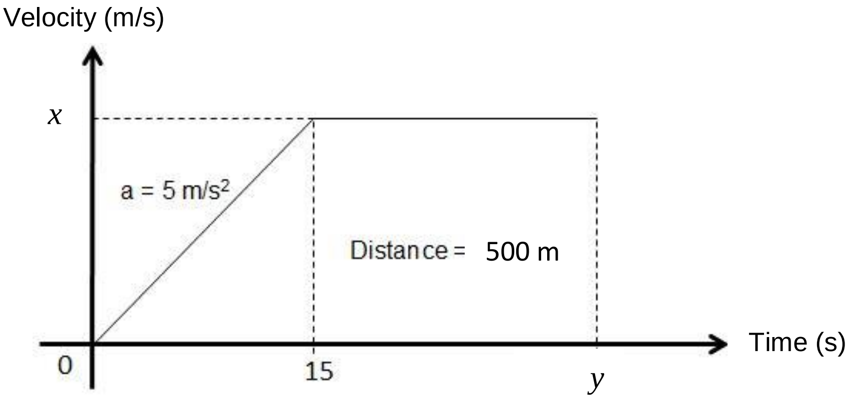

Figure 4

Given that the car accelerates at 5 m/s^2 from time t = 0 s to t = 15 s, and travels 500 m from time t = 15 s to t = y s,

a) Calculate the value of x.

b) Calculate the value of y.

a) Gradient of the graph from t = 0 s to t = 15 s = 5 m/s^2.
So x/15 = 5
x = 75

b) Area under the graph from t = 15 s to t = y s is 500 m
(y - 15) × x = 500
(y - 15) × 75 = 500
y = 21.67

10. Figure 5 shows a constant force of 50 N exerted horizontally on a 2 kg object. The object moves with a constant velocity.

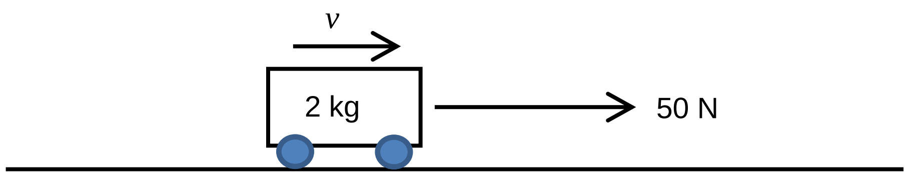

Figure 5

What is the magnitude of the acceleration of the object? Explain your answer.
0 m/s^2 since the object is moving with a constant velocity.

11. Figure 6 shows four forces acting on a 4 kg object.

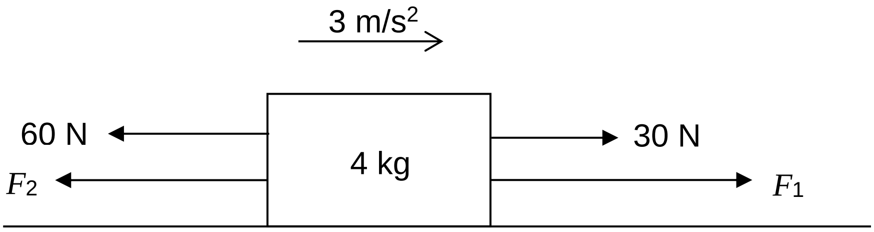

Figure 6

Given that the magnitude of F_1 is two times that of F_2 and the acceleration of the object is 3 m/s^2 to the right as shown in Figure 6,

a) Determine the magnitude of the net force acting on the object.

b) Determine the magnitude of F_1 and F_2.

a) Net force = ma
Net force = 4 kg × 3 m/s^2
= 12 N

b) From the figure, we know that the four forces will "combine" to become the net force of 12 N.
$\Rightarrow F_1$ + 30 N – F_2 – 60 N = 12 N
$\Rightarrow F_1 - F_2$ = 12 N – 30 N + 60 N
$\Rightarrow F_1 - F_2$ = 42 N
Now, we know that F_1 is two times of F_2, so if we let F_2 be x, then F_1 has to be $2x$.
So we have
$\Rightarrow 2x - x$ = 42 N
$\Rightarrow x$ = 42 N

This means F_2 = 42 N, and F_1 = 84 N since F_1 is $2x$.

12. Figure 7 shows 8 kg object sliding down a slope inclined at 20°. Take g = 10 m/s^2.

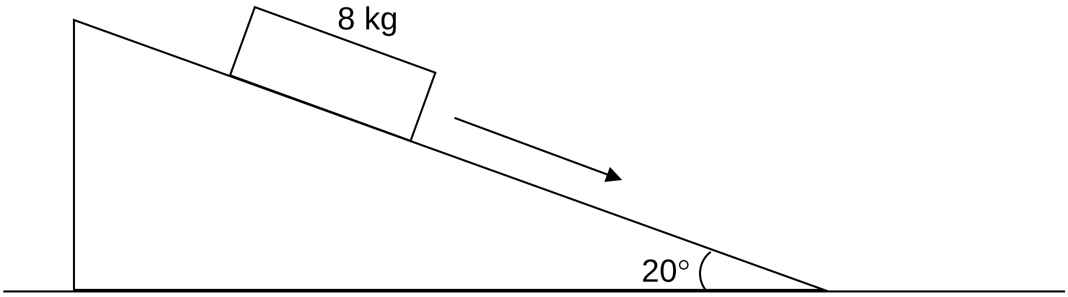

Figure 7

a) Determine the magnitude of the net force that is acting on the object in the direction of motion as shown assuming that the slope is frictionless.

b) Determine the magnitude of the acceleration of the object in the direction of the motion assuming that the slope is frictionless.

c) Determine the magnitude of the normal reaction force acting on the object from the slope.

d) If the 8 kg object is replaced with a 16 kg object, would the magnitude of the acceleration in the direction of the motion be doubled?

e) If there is a frictional force of 20 N along the slope, determine the magnitude of the net force that is acting on the 8 kg object.

a) The magnitude of the net force is $mg \sin\theta = 8 \times 10 \times \sin 20° = 27.4$ N

b) The magnitude of the acceleration is $g \sin\theta = 10 \times \sin 20° = 3.42$ m/s^2

c) The magnitude of the normal reaction force is $mg \cos\theta = 8 \times 10 \times \cos 20° =$ 75.2 N

d) Note that the acceleration is given by $g \sin\theta$, it only depends on the angle and not the mass, so replacing the 8 kg by a 16 kg object will not increase the acceleration.

e) If there is a frictional force of 20 N, then the magnitude of the net force will be 27.4 – 20 = 7.4 N (the 27.4 N is obtained from part a).

13. Find the magnitude of the acceleration of a 5 kg stationary object resting on a table when subjected to an applied force of 50 N as shown in Figure 8. You may assume that friction is negligible.

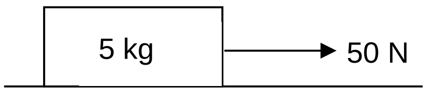

Figure 8

Using $F = ma$, magnitude of acceleration = F/m = 50/5 = 10 m/s^2

14. A non-uniform wooden plank of length 200 cm is hung using two strings attached to both ends. Figure 9 shows the free-body diagram of the plank, in which F_1 and F_2 is the tension in the string at each end respectively and W is the weight of the plank. The magnitude of F_1 is 45 N and W could be considered to be acting at a point which is 30 cm away from the thicker end of the plank. The plank is in static equilibrium.

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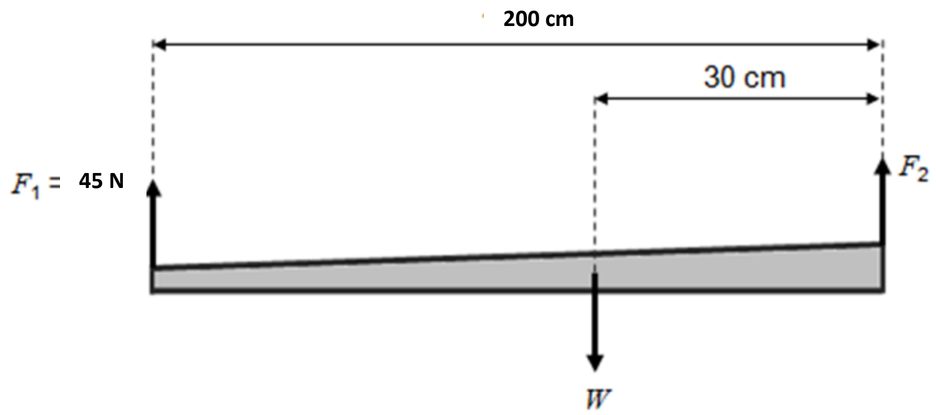

Figure 9

a) Determine the magnitude of W.

b) Determine the magnitude of F_2.

a) Taking moments about right end of the plank,
Sum of clockwise moments = sum of anticlockwise moments
45 N × 2 m = W × 0.3 m
W = 300 N

b) $F_1 + F_2 = W \Rightarrow 45\text{ N} + F_2 = W$
F_2 = 300 N – 45 N = 255 N

15. By taking g = 10 m/s^2, determine the magnitude of the force F depicted in Figure 10.

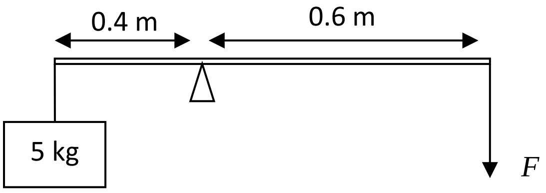

Figure 10

Taking moments about the pivot,
Sum of anti-clockwise moments = sum of clockwise moments
50 N × 0.4 m = F × 0.6 m
20 Nm = 0.6 F
F = 20/0.6
F = 33.33 N

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16. By taking g = 10 m/s^2, determine the magnitude of the force F depicted in Figure 11.

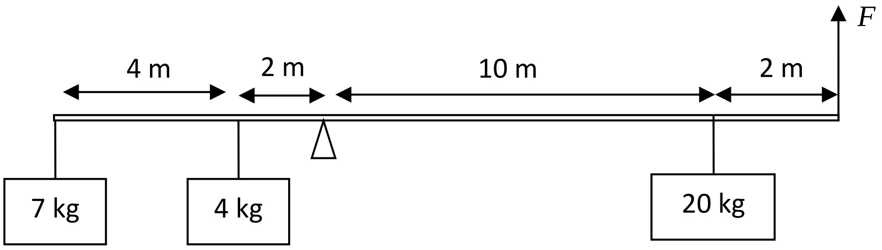

Figure 11

We will take moments about the pivot.

Clockwise moments
200 N × 10 m = 2000 Nm

Anti-clockwise moments
70 N × 6 m = 420 Nm
40 N × 2 m = 80 Nm
F N × 12 m = 12F Nm

Sum of anti-clockwise moments = sum of clockwise moments
2000 = 420 + 80 + 12F
2000 – 420 – 80 = 12F
1500 = 12F
F = 1500 / 12 = 125 N

17. Determine the tension T for the scenario depicted in Figure 12.

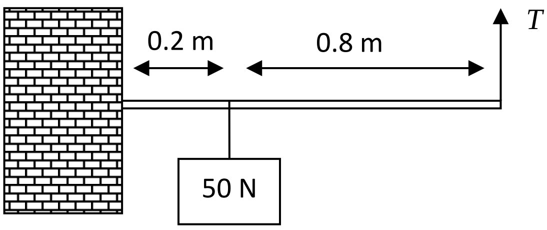

Figure 12

Taking moments about left end of the rod,
Sum of anticlockwise moments = sum of clockwise moments
T × 1 = 50 × 0.2
T = 10 N

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