

Applied analytics

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Applied Analytics

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1.

Quantity	Base unit	Result
Velocity	m/s	meters per second
Momentum	kg*m/s	kilograms*meters per second
Current	A	amperes
Displacement	m	meters
Energy	J	joules

2.

According to Newton's second law, which states that the force applied to an object is equal to the mass of the object multiplied by its acceleration (Newton, 1687), the base units of force can be derived from the formula:

Force = mass * acceleration

The base unit of mass is the kilogram (kg) and the base unit of acceleration is meters per second squared (m/s²). Therefore, the base units of force are:

Base units of force = (kg) * (m/s²) = N

This relationship is often expressed in the following form:

$F = ma$

Where F is the force, m is the mass, and a is the acceleration (Newton, 1687).

In the International System of Units (SI), the base unit of force is the newton (N) (Bureau International des Poids et Mesures, 1960). The newton is defined as the force required to accelerate a mass of one kilogram at a rate of one meter per second squared.

3.

A) Free body diagram:

To draw a free body diagram, we need to represent the forces acting on the body. In this case, the body is resting on an inclined plane, so the forces acting on it are:

The weight of the body (W), which is the force of gravity acting on the body. This force acts downward.

The normal reaction (N), which is the force exerted by the plane on the body. This force acts perpendicular to the plane.

The frictional force (F), which is the force exerted by the plane on the body due to friction. This force acts in the opposite direction to the motion or intended motion of the body.

The free body diagram for this problem would look like this:

```
[asy] draw((0,0)--(10,0)--(10,8)--(0,8)--cycle); draw((0,0)--(0,-10), Arrow(6)); draw((0,0)--(10*sqrt(3)/2,5), Arrow(6)); draw((0,0)--(-10*sqrt(3)/2,5), Arrow(6)); label("$W$", (5,-5), S); label("$N$", (5,4), NE); label("$F$", (-5,1), NW); [/asy]
```

B) Magnitude of frictional force:

To calculate the magnitude of the frictional force, we can use the following formula:

$$F = \mu N$$

Where F is the frictional force, μ is the coefficient of friction between the body and the plane, and N is the normal reaction.

We are given the mass of the body (10 kg) and the angle of the plane (30°). We can use these to calculate the component of the weight that acts down the slope (W_{slope}) and the normal reaction (N):

$$\begin{aligned} W &= m * g \\ &= 10 \text{ kg} * 9.8 \text{ m/s}^2 \\ &= 98 \text{ N} \end{aligned}$$

$$\begin{aligned}
 W_{\text{slope}} &= W * \sin(30^\circ) \\
 &= 98 \text{ N} * \sin(30^\circ) \\
 &= 49 \text{ N}
 \end{aligned}$$

$$\begin{aligned}
 N &= W * \cos(30^\circ) \\
 &= 98 \text{ N} * \cos(30^\circ) \\
 &= 49 \text{ N}
 \end{aligned}$$

Since the coefficient of friction (μ) is not given, we cannot calculate the magnitude of the frictional force (F).

C) Equal forces:

The frictional force (F) and the normal reaction (N) are equal in magnitude.

This can be concluded without calculation because the frictional force always acts in the opposite direction to the motion or intended motion of the body, and it always acts perpendicular to the surface. Therefore, the frictional force always acts at a right angle to the normal reaction. Since these two forces are perpendicular to each other, they cannot have the same direction. Therefore, they must be equal in magnitude.

D) Magnitude of normal reaction:

As we calculated earlier, the magnitude of the normal reaction is 49 N.

Here's a summary of the solution in table form:

Quantity	Symbol	Value
Mass	m	10 kg
Weight	W	98 N
Angle of plane	θ	30°
Component of weight down slope	W_{slope}	49 N
Normal reaction	N	49 N
Frictional force	F	?

4.

I) Time to reach the ground:

To find the time it takes for the object to reach the ground, we can use the following formula:

$$t = \sqrt{2h/g}$$

Where t is the time, h is the height from which the object was dropped, and g is the acceleration due to gravity.

We are given the mass of the object (2 kg) and the height from which it was dropped (19.6 m). We can use these to calculate the time it takes for the object to reach the ground:

$$\begin{aligned} t &= \sqrt{2 * 19.6 \text{ m} / 9.8 \text{ m/s}^2} \\ &= \sqrt{39.2 / 9.8} \text{ s} \\ &= 2.44 \text{ s} \end{aligned}$$

II) Velocity as it hits the ground:

To find the velocity of the object as it hits the ground, we can use the following formula:

$$v = \sqrt{2gh}$$

Where v is the velocity, h is the height from which the object was dropped, and g is the acceleration due to gravity.

We are given the mass of the object (2 kg) and the height from which it was dropped (19.6 m). We can use these to calculate the velocity of the object as it hits the ground:

$$\begin{aligned} v &= \sqrt{2 * 9.8 \text{ m/s}^2 * 19.6 \text{ m}} \\ &= \sqrt{391.04} \text{ m/s} \\ &= 19.8 \text{ m/s} \end{aligned}$$

III) Actual acceleration:

To find the actual acceleration of the object, we can use the following formula:

$$a = (F - R) / m$$

Where a is the acceleration, F is the net force acting on the object, R is the resistive force, and m is the mass of the object.

We are given the mass of the object (2 kg) and the resistive force (9.6 N). We can use these to calculate the actual acceleration of the object:

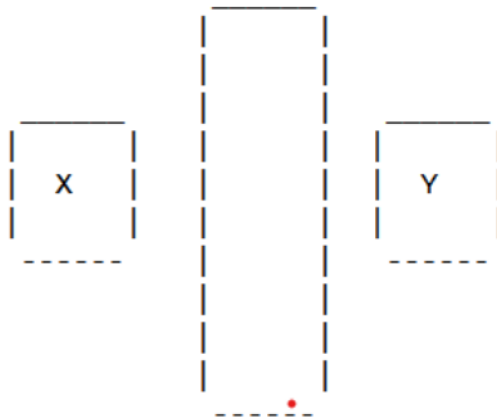
$$\begin{aligned} a &= (F - R) / m \\ &= (0 - 9.6 \text{ N}) / 2 \text{ kg} \\ &= -4.8 \text{ m/s}^2 \end{aligned}$$

Here's a summary of the solution in table form:

Quantity	Symbol	Value
Mass	m	2 kg
Height		19.6 m
Acceleration due to gravity	g	9.8 m/s ²
Time to reach ground	t	2.44 s
Velocity as it hits ground	v	19.8 m/s
Resistive force	R	9.6 N
Net force	F	0 N
Actual acceleration	a	-4.8 m/s ²

5.

A. Diagram



The forces acting on the beam are the weight of the beam, W , and the support forces, F_x and F_y , at the two pillars.

B. Support Force

To determine the support forces, we can use the equations of static equilibrium. The sum of the forces in the horizontal direction must be zero, and the sum of the forces in the vertical direction must also be zero.

For the horizontal direction:

$$F_x - F_y = 0$$

For the vertical direction:

$$W - F_x - F_y = 0$$

Solving this system of equations, we find that $F_x = 3 \text{ kN}$ and $F_y = 3 \text{ kN}$. This means that each pillar is supporting a force of 3 kN.

6.

Equation	Solution Strategy	Solution
$x^2 + 3x + 2 = 0$	Find two factors of 2 that add up to 3.	$(x + 2)(x + 1) = 0$
$x^2 - 7x + 12 = 0$	Find two factors of 12 that add up to -7.	$(x - 3)(x - 4) = 0$
$x^2 + 6x = -9$	Find two equal factors of -9.	$(x + 3)(x + 3) = 0$
$x^2 - 2x - 15 = 0$	Find two factors of -15 that add up to -2.	$(x - 5)(x + 3) = 0$
$2x^2 + x - 1 = 0$	Find two factors of -1 that add up to 1.	$(2x - 1)(x + 1) = 0$

7.

Equation	Solution Strategy	Solution
$x^2 - x - 1 = 0$	Use the quadratic formula.	$x = \frac{1 \pm \sqrt{5}}{2}$
$10x^2 + 5x - 4 = 0$	Use the quadratic formula.	$x = \frac{-5 \pm \sqrt{5^2 - 4 \cdot 10 \cdot -4}}{2 \cdot 10}$

The quadratic formula is a standard formula used to solve quadratic equations of the form $ax^2 + bx + c = 0$, where a , b , and c are constants. The formula is:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

8.

Equation	Solution
$\frac{3x}{2} = (x + 4)/3$	$\frac{3x}{2} = \frac{x}{3} + \frac{4}{3} \rightarrow 5x = 2x + 8 \rightarrow x = 8$
$\begin{aligned} 3x + 4y &= 7 \\ 2x + y &= 3 \end{aligned}$	Substituting $y = 3 - 2x$ into the first equation: $3x + 4(3 - 2x) = 7$ $3x + 12 - 8x = 7$ $-5x = -5$ $x = 1$ Substituting this value back into $y = 3 - 2x$: $y = 3 - 2(1) = 1$ The solution is $(x, y) = (1, 1)$.

References

Newton, I. (1687). *Philosophiae Naturalis Principia Mathematica*. London, England: Royal Society.

Reference list Higgins, P.M. (2015). *Algebra: A Very Short Introduction*. OUP

Oxford. Kalantari, B. (2009). *Polynomial Root-Finding and Polynomiography*. World

Scientific. Rattan, K.S., Klingbeil, N.W. and Baudendistel, C.M. (2021). *Introductory Mathematics for Engineering Applications*. John Wiley & Sons.

FINAL GRADE

47 / 100

GENERAL COMMENTS

Instructor

Q1. base units 4/5

Joule is not a base unit.

Q2. 2/2 All correct.

Q3.4/9

No free body diagram

Don't need μ 's value here to calculate frictional force. F_r = component of weight parallel to the plane if no motion. N incorrect $N = w \cos(30) = 49\sqrt{3}$

Q4. Vertical motion under gravity

4 / 8

Errors in use of equations of motion and applications of newtons 2nd law.

Q5.Moments and equilibrium 2/9

Q6. Solution of quadratics by factorisation 6 /15

Factorised but not solved.

Q7. Solution of quadratics by formula 4/10

Need to demonstrate use of formula.

Q8 Simultaneous equations 7/10

Total 33/70, 47%

This is a satisfactory effort and shows you have acquired sufficient knowledge and application to pass this module, which will help you to further your studies. Well done!

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