Moments, Energy and Accelerated Motion

Name: ______________________________

Class: ______________________________

1. A uniform metre rule of weight W rests horizontally on two supports at the 10 cm and 70 cm marks. What is the reaction at the support at the 10 cm mark?

A. $\frac{1}{4}W$

B. $\frac{1}{3}W$

C. $\frac{1}{2}W$

D. $\frac{2}{3}W$

2. A uniform light rigid rod of length 1.5 m is hinged smoothly at end O and kept horizontal by a vertical light string attached at a point 0.50 m from O. A load of 24 N hangs from the free end of the rod. Find the tension in the string. Neglect the weight of the rod.

A. $24\ \mathrm{N}$

B. $36\ \mathrm{N}$

C. $48\ \mathrm{N}$

D. $72\ \mathrm{N}$

3. A non-uniform rod AB of length 0.90 m is supported horizontally by two vertical strings at A and B. The tensions are 12 N at A and 18 N at B. How far from A is the centre of gravity of the rod?

A. $0.36\ \mathrm{m}$

B. $0.45\ \mathrm{m}$

C. $0.54\ \mathrm{m}$

D. $0.60\ \mathrm{m}$

4. A 0.50 kg package slides from rest down a smooth curved track from a height of 1.8 m above the lowest point. Neglect air resistance. Take $g = 10\ \mathrm{m\,s^{-2}}$. What is its speed at the lowest point?

A. $3.0\ \mathrm{m\,s^{-1}}$

B. $4.2\ \mathrm{m\,s^{-1}}$

C. $6.0\ \mathrm{m\,s^{-1}}$

D. $9.0\ \mathrm{m\,s^{-1}}$

5. A block of mass 1.0 kg is projected up a rough incline with initial kinetic energy 40 J. At the highest point its gravitational potential energy has increased by 25 J and it is instantaneously at rest. How much work is done against friction during the upward journey?

A. $15\ \mathrm{J}$

B. $25\ \mathrm{J}$

C. $40\ \mathrm{J}$

D. $65\ \mathrm{J}$

6. Identical blocks start from rest at the same height H and slide to the bottom along two different smooth paths in a vertical plane: path (1) is a steeper short straight incline; path (2) is a longer gentler curve. Let speeds at the bottom be v_1 and v_2, and times taken be t_1 and t_2. Neglect air resistance. Which is correct?

A. $v_1 > v_2$ and $t_1 = t_2$

B. $v_1 = v_2$ and $t_1 = t_2$

C. $v_1 = v_2$ and $t_1 < t_2$

D. $v_1 > v_2$ and $t_1 < t_2$

7. A trolley starts from rest and moves with uniform acceleration along a straight track. It travels 4.5 m in the first 3.0 s. How far does it travel in the next 3.0 s?

A. $4.5\ \mathrm{m}$

B. $9.0\ \mathrm{m}$

C. $13.5\ \mathrm{m}$

D. $18\ \mathrm{m}$

8. A skateboarder moves straight ahead at 8.0 m s$_{-1}$ and then brakes uniformly, coming to rest in 16 m. Find the magnitude of the uniform deceleration.

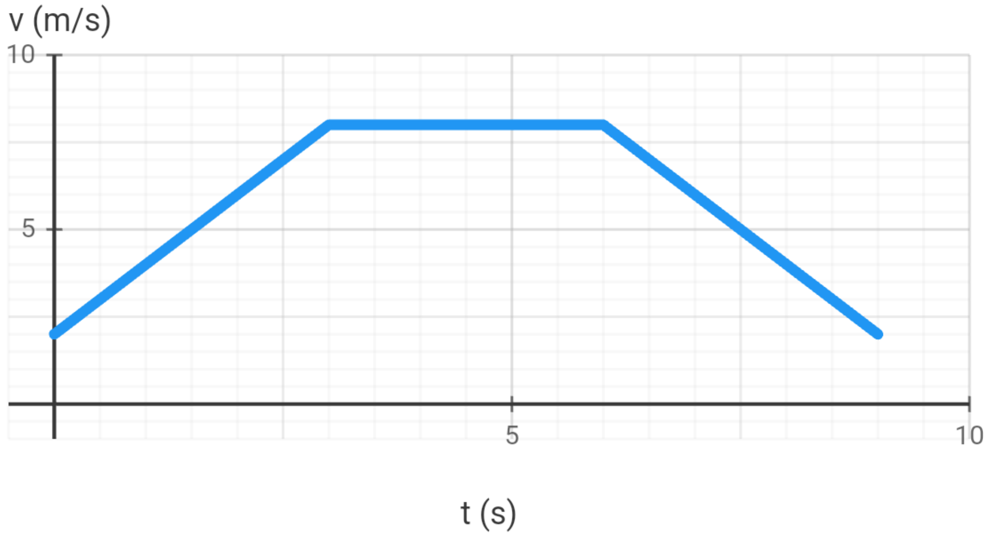
A. $0.50\ \mathrm{m\,s^{-2}}$

B. $2.0\ \mathrm{m\,s^{-2}}$

C. $4.0\ \mathrm{m\,s^{-2}}$

D. $8.0\ \mathrm{m\,s^{-2}}$

9. The velocity–time graph of a particle moving along a straight line is shown below.



In which time interval is the acceleration of the particle negative?

A. $0\ \mathrm{s} < t < 3\ \mathrm{s}$

B. $3\ \mathrm{s} < t < 6\ \mathrm{s}$

C. $6\ \mathrm{s} < t < 9\ \mathrm{s}$

D. Acceleration is negative throughout

10. Blocks X (3.0 kg) and Y (5.0 kg) rest on a smooth horizontal surface and are connected by a light inextensible string. A horizontal force of 24 N pulls Y away from X so that both accelerate together. What is the tension in the string?

A. $9.0\ \mathrm{N}$

B. $12\ \mathrm{N}$

C. $15\ \mathrm{N}$

D. $24\ \mathrm{N}$

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答案

1 B

For a uniform metre rule the centre of gravity is at the 50 cm mark, so weight W acts there.

Take moments about the support at 70 cm (clockwise positive for weight):
Moment arm of W about 70 cm = $70 - 50 = 20$ cm.
Moment arm of reaction R_{10} about 70 cm = $70 - 10 = 60$ cm.
Equilibrium of moments:
$R_{10} \times 60 = W \times 20$
$R_{10} = \frac{20}{60}W = \frac{1}{3}W.$

(Vertical force balance: $R_{10} + R_{70} = W$, so $R_{70} = \frac{2}{3}W$, which is consistent.)

2 D

Take moments about the hinge O. The hinge force has zero moment about O.

Clockwise moment due to the load: $24 \times 1.5 = 36$ N m.
Anticlockwise moment due to tension T: $T \times 0.50$.
For equilibrium:
$T \times 0.50 = 36$
$T = 72$ N.

3 C

The rod is in equilibrium, so the total upward force equals the weight:
$W = 12 + 18 = 30$ N, acting at the centre of gravity G, a distance x from A.

Take moments about A:
$W \times x = 18 \times 0.90$
$30x = 16.2$
$x = 0.54$ m.

(Check about B: $12 \times 0.90 = 30 \times (0.90 - x)$ also gives $x = 0.54$ m.)

4 C

The track is smooth, so mechanical energy is conserved. Loss in gravitational potential energy equals gain in kinetic energy.

$mgh = \frac{1}{2}mv^2$

Cancel m:

$gh = \frac{1}{2}v^2$

$v^2 = 2gh = 2 \times 10 \times 1.8 = 36$

$v = 6.0\ \mathrm{m\,s^{-1}}$.

Only the height difference matters; the shape of the path does not affect the speed at the bottom.

5 A

With friction present, the initial mechanical energy equals the final mechanical energy plus energy dissipated by friction.

At the highest point, kinetic energy is zero and GPE has increased by 25 J.

$40 = 25 + W_{\text{against friction}}$

$W_{\text{against friction}} = 15\ \mathrm{J}$.

That work against friction appears as an increase in internal energy (heat).

6 C

Both paths are smooth, so only gravity does work and mechanical energy is conserved. The same loss in GPE gives the same gain in KE, so $v_1 = v_2$.

Path (2) is longer and the average acceleration along the path is smaller, so the time taken is longer: $t_1 < t_2$.

Therefore $v_1 = v_2$ and $t_1 < t_2$.

7 C

Use $s = ut + \frac{1}{2}at^2$ with $u = 0$.

First 3.0 s: $4.5 = \frac{1}{2}a(3.0)^2 = 4.5a \Rightarrow a = 1.0\ \mathrm{m\ s^{-2}}$.

Total distance in 6.0 s: $s_6 = \frac{1}{2}(1.0)(6.0)^2 = 18\ \mathrm{m}$.
Distance in the next 3.0 s: $18 - 4.5 = 13.5\ \mathrm{m}$.

(Successive equal times from rest give distances in the ratio 1 : 3, so second interval is three times the first: $3 \times 4.5 = 13.5\ \mathrm{m}$.)

8 B

Use $v^2 = u^2 + 2as$ with final speed zero.

$0 = 8.0^2 + 2a(16)$
$0 = 64 + 32a$
$32a = -64$
$a = -2.0\ \mathrm{m\ s^{-2}}$.
Magnitude of deceleration is $2.0\ \mathrm{m\ s^{-2}}$.

9 C

On a velocity–time graph, acceleration is the gradient of the graph.

From 0 to 3 s the line slopes upward: acceleration is positive.
From 3 to 6 s the line is horizontal: acceleration is zero (constant velocity).
From 6 to 9 s the line slopes downward: acceleration is negative.

10 A

First find the common acceleration of the system.
Total mass = $3.0 + 5.0 = 8.0$ kg.
$F = ma \Rightarrow 24 = 8.0\,a \Rightarrow a = 3.0\ \mathrm{m\,s^{-2}}$.

Consider block X: the only horizontal force on X is the tension T.
$T = m_X a = 3.0 \times 3.0 = 9.0\ \mathrm{N}$.

(Check with Y: $24 - T = 5.0 \times 3.0 \Rightarrow T = 9.0\ \mathrm{N}$.)