Test 2

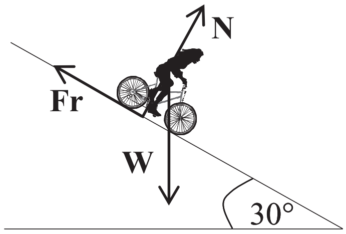
Core short answer questions: 50 marks
Suggested time: 60–70 minutes

Core short answer questions

Specific instructions to students

- Answer **all** questions in the spaces provided.
- For all questions which require a numerical answer you must show all working.
- You should take the value of g to be 10 ms^{-2}.

A bicycle and rider are accelerating at a rate of 1 ms^{-2} down a slope inclined at an angle of 30° to the horizontal.



QUESTION 1 — 3 marks

On the diagram above, use labelled arrows to represent the following forces:

- W = weight of bicycle and rider (as one force),
- Fr = total frictional forces (as one force),
- N = normal reaction force on bicycle and rider (as one force).

QUESTION 2 — 2 marks

Calculate the size of the component of the acceleration due to gravity that acts on the bicycle and rider parallel to the slope.

$g_{parallel} = g \sin\theta$
$= 10 \times \sin30°$
$= 5\ ms^{-2}$

Answer:

5 ms^{-2}

QUESTION 3 — 3 marks

If the total frictional forces acting on the bicycle and rider are 250 N up the slope, calculate the mass of the bicycle and rider to the nearest kilogram.

$F_{net} = F_{gravity\ down\ slope} - F_{friction}$
mass × 1 = mass × 5 − 250
5 × mass − 1 × mass = 250
4 × mass = 250
mass = 250 ÷ 4 = 62.5 kg

Answer:

62.5 kg

QUESTION 4 — 2 marks

Complete the table below showing the size of the three forces mentioned in question 1.

a	Weight of bicycle and rider $W = mg = 62.5 \times 10 = 625$ N	625 N
b	Total frictional forces	250 N
c	Normal reaction force $N = mg\cos\theta = 62.5 \times 10 \times \cos30° = 541$ N	541 N

QUESTION 5 — 4 marks

Jeff and Ali are comparing their throwing techniques on the school oval to see who can throw a cricket ball the farthest distance.

Jeff throws his ball at an angle of 30° to the horizontal with a launch speed of 21 ms^{-1}.

Ali throws his ball at an angle of 41° to the horizontal with a launch speed of 18 ms^{-1}.

Perform calculations to determine who throws their ball the farthest distance? (Assume the balls are launched from very close to the Earth's surface and that the school oval is flat.)

The equations of motion can be used but an easier method is to use the range equation:

$R = U^2 \sin2\theta / g$

Jeff: $R = 21^2 \times \sin(2 \times 30°) \div 10 = 38.19$ m

Ali: $R = 18^2 \times \sin(2 \times 41°) \div 10 = 32.08$ m

Answer:

Therefore, Jeff throws his ball the farthest distance.

QUESTION 6 — 4 marks

Perform calculations to determine whose ball is in the air for a longer period of time?

Again the equations of motion can be used but so can the time of flight equation:

$t = 2U\sin\theta / g$

Jeff: $t = 2 \times 21 \sin30° \div 10 = 2.10$ s

Ali: $t = 2 \times 18 \sin41° \div 10 = 2.36$ s

Answer:

Therefore, Ali's ball is in the air for a longer period of time.

A car is travelling around a flat circular corner at a constant speed of 55 kmh^{-1}. The corner has a radius of 27 m. The mass of the car and the occupants is 1400 kg.

QUESTION 7 **3 marks**

What is the size of the centripetal acceleration of the car and occupants during this motion?

$v = 55 \div 3.6 = 15.28\ ms^{-1}$

$a = v^2 / r$

$= 15.28^2 \div 27$

$= 8.64\ ms^{-2}$

Answer:

$8.6\ ms^{-2}$

QUESTION 8 **2 marks**

What is the size of the centripetal force acting on the car and occupants?

$F = ma$

$= 1400 \times 8.64$

$= 12096$ N

Answer:

1.2×10^4 N

QUESTION 9 **2 marks**

What is the maximum speed that the car can safely take this corner at if the sideways frictional force cannot exceed 18 000 N or the car will skid off the road?

$mv^2 / r \leq 18000$ to prevent skidding off

$1400\ v^2 / 27 \leq 18000$

$v \leq \sqrt{(18000 \times 27 \div 1400)}$

$v \leq 18.63\ ms^{-1}$

Answer:

$18.6\ ms^{-1}$

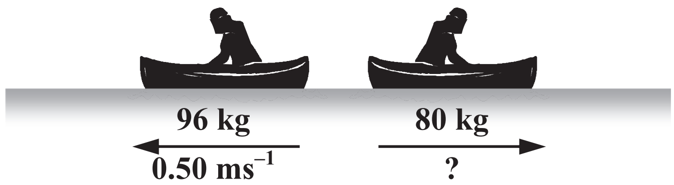
QUESTION 10 **2 marks**

If the corner was banked, a higher safe maximum cornering speed would be possible. Why is this?

Answer:

On a banked road a component of the normal reaction force of the road on the car adds to the friction to give a higher centripetal acceleration and hence a higher cornering speed.

Two people in two boats on a still lake push off from each other and travel in opposite directions at constant speeds as shown in the diagram below.



QUESTION 11 **2 marks**

Find the magnitude of the momentum of the left hand boat and its occupant if the total mass is 96 kg and it moves to the left at a constant speed of 0.5 ms^{-1} after pushing off.

$p = mv$

$= 96 \times 0.50$

$= 48\ kgms^{-1}$

Answer:

$48\ kgms^{-1}$

QUESTION 12 **2 marks**

Find the constant speed of the right hand boat and its occupant after pushing off, if the total mass is 80 kg and momentum is conserved during the push.

$p = 48$

$= 80 \times v$

Therefore, $v = 48 \div 80 = 0.6\ ms^{-1}$

Answer:

$0.6\ ms^{-1}$

QUESTION 13 **2 marks**

Crumple zones and airbags are used as car safety devices because they reduce the impact of forces acting on the passengers during a collision. One way they achieve this is by which of the following?

A reducing the change in the car's momentum during a collision

B increasing the change in the car's momentum during a collision

C reducing the time over which the collision forces act

D increasing the time over which the collision forces act

Answer:

D

Since impulse = change in momentum = force × time, if the time of the collision is increased, the force is reduced for a constant change in momentum.

A spring loaded toy uses a spring of spring constant 18 Nm^{-1} compressed a distance of 6 cm to launch a small projectile of mass 65 g.

QUESTION 14 **2 marks**

How much strain potential energy is stored in the spring when it is compressed by 6 cm?

SPE = ½ kx^2
= ½ × 18 × 0.06^2
= 0.0324 or 3.2 × 10^{-2} J

Answer:

3.2 × 10^{-2} J

QUESTION 15 **3 marks**

Assuming all the strain potential energy is converted into kinetic energy, what is the launch speed of the projectile when the spring is released?

SPE = KE = ½ mv^2
$v = \sqrt{(2 \times KE \div m)}$
$= \sqrt{(2 \times 0.0324 \div 0.065)}$
= 0.998 or 1.0 ms^{-1}

Answer:

1.0 ms^{-1}

QUESTION 16 **2 marks**

The manufacturers of the toy want the projectile to obtain a launch speed of 2 ms^{-1} from a 6 cm compression of the spring. What spring constant is needed to achieve this?

½ mv^2 = ½ kx^2
$k = mv^2 \div x^2$
= 0.065 × 2^2 ÷ 0.06^2
= 72.2 or 72 Nm^{-1}

Answer:

72 Nm^{-1}

QUESTION 17 **3 marks**

What is the size of the Earth's gravitational field at an **altitude** of 900 km above the Earth's surface?

$g = GM/r^2$
= 6.67 × 10^{-11} × 5.98 × 10^{24}
÷ (6.38 × 10^6 + 900 × 10^3)^2
= 7.526 or 7.5 Nkg^{-1}

Answer:

7.5 Nkg^{-1}

QUESTION 18 **3 marks**

What would be the speed of a satellite of mass 1800 kg placed into a stable orbit at this height?

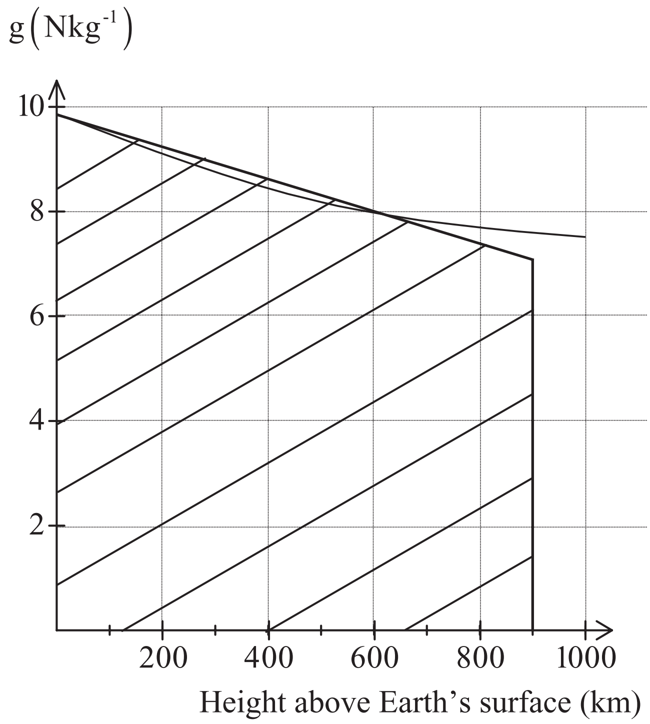
$g = v^2/r$
$v = \sqrt{(gr)}$
$= \sqrt{(7.526 \times (6.38 \times 10^6 + 900 \times 10^3))}$ = 7400 ms^{-1}

Answer:

7400 ms^{-1}

QUESTION 19 **4 marks**

Use the graph below to estimate the increase in gravitational potential energy when this satellite is launched from the surface of the Earth and placed into a stable orbit at a height of 900 km above the Earth.



Estimate the area under the graph up to a height of 900 km.
area = ½ (9.8 + 7.2) × 900 × 10^3 = 7.65 × 10^6 Jkg^{-1}
GPE increase = area × mass of satellite
= 7.65 × 10^6 × 1800 = 1.4 × 10^{10} J (approx)
OR
The counting squares method gives approx 19 squares and each square
= 200000 × 2 = 4 × 10^5 Jkg^{-1}
GPE = 19 × 4 ×10^5 × 1800 = 1.37 × 10^{10} J

Answer:

Anything between 1.32 and 1.42 × 10^{10} J is correct.