WILLETTON SENIOR HIGH SCHOOL

A LEADING SCHOOL - CELEBRATING ACHIEVEMENT

PHYSICS 11:(2AB)

KD 20.3.12

Forces and Energy Test 2012

Name: Marking Key

Teacher: (Tick)

Mr Taylor	☐	1		
Mr Singh	☐	2		
Mr Dopson	☐	3	☐	4
Mrs Munshi	☐	5		
Mrs Davies	☐	6		

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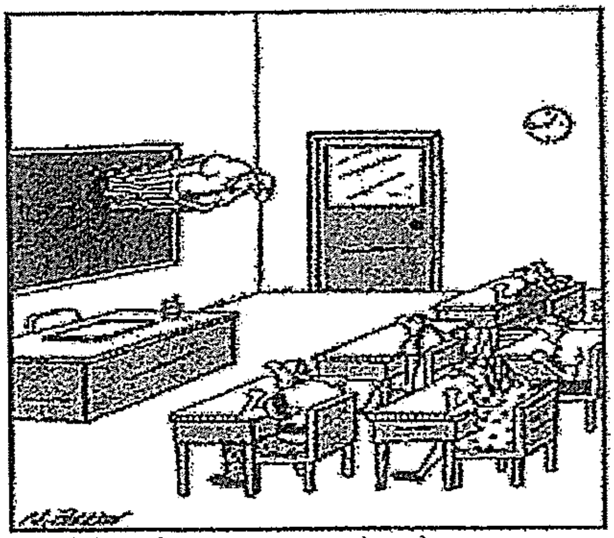
Time: 1 Hour

* A data sheet is supplied for student use

Note:

1. Calculations must show clear working with answers written in scientific notation stated to three significant figures..
2. Full Marks will be allocated for clear and logical setting out.
3. To help identify your answer, underline each answer.
4. State assumptions if working on open ended type questions.
5. Not all questions carry equal number of marks.



"Good morning, and welcome to The Wonders of Physics."

For all Qus — ½ for incorrect No sigfig and/or using scientific notation

1. (3 marks)
A skydiver with a parachute has a total mass of 80.0 kg experiences an air resistance of 5.10×10^2 N while free-falling. Calculate the resultant acceleration of the skydiver.

$F_{AIR} = 5.10 \times 10^2$ N
$m = 80.0$ kg

$F_W = mg$
$= 80.0 \times (-9.8)$
$= -784$ N ½

$F_R = F_{AIR} + F_W$ ½
$= 5.10 \times 10^2 + (-784)$
$= -274$ N ½

$F_R = ma$
$a = F_R / m$ ½
$= -274 / 80.0$
$= -3.42$ ms^{-2}

½ ½

ie/ $\underline{a = 3.42 \text{ ms}^{-2} \text{ down}}$

2. (2 marks)
What is the work done by the brakes of a 1.50×10^3 kg car as they slow the car from 2.50 m s^{-1} to 1.00 m s^{-1} over a distance of 8.00 m?

$m = 1.50 \times 10^3$ kg
$u = 2.50$ ms^{-1}
$v = 1.00$ ms^{-1}
$s = 8.00$ m

$W = \Delta E$ ½
$= \frac{1}{2} m (v^2 - u^2)$
½ $= \frac{1}{2} \times 1.50 \times 10^3 (2.50^2 - 1.00^2)$
$= \underline{3.94 \times 10^3 \text{ J}}$
½ ½

OR

$a = (v^2 - u^2)/2s$
$= (2.50^2 - 1.00^2)/2 \times 8.00$
$= 0.328$ ½
$F = ma = 1.50 \times 10^3 \times 0.328$
$= 492$ N ½
$W = Fs$
$= 492 \times 8.00$
$= \underline{3.94 \times 10^3 \text{ J}}$
½ ½

3. A 10.0 kg ball falls from a height of 5.00 m and rebounds from the floor to a height of 3.00 m.

(a) (2 marks)
Calculate the energy lost by the ball?

$m = 10.0$ kg
$h_i = 5.00$ m
$h_f = 3.00$ m
$g = -9.8$ m

$\Delta E = mg(h_f - h_i)$ ½
$= 10.0 \times 9.8 (3.00 - 5.00)$ ½
$= 196$ J
$\therefore$ $\underline{\text{Energy lost} = 1.96 \times 10^2 \text{ J}}$ ½
½

(b) (2 marks)
What happens to the energy lost by the ball?

Energy lost in
sound
heat
friction
air resistance

$\Big\}$ any 2 — 1 mark each

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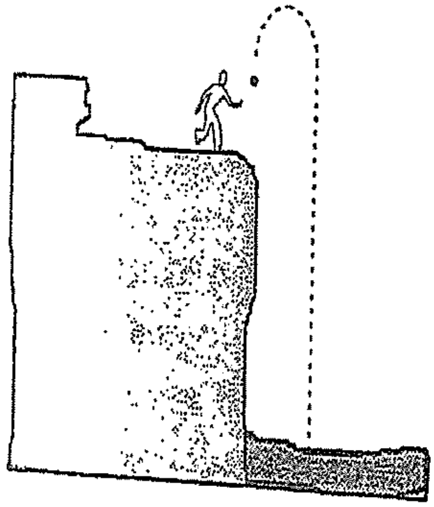
4. A sketch of a rock thrown on the moon's surface



An astronaut throws a rock vertically upwards on the lunar surface with a velocity of 15.0m s^{-1} , given that the moon's 'g' value is 1.60 m s^{-2} , determine the following.

(a) (2 marks)
The time it would take the rock to reach its maximum height.

$u = 15.0 ms^{-1}$
$v = 0.00 ms^{-1}$
$g = -1.60 ms^{-2}$
$t = ?$

$v = u + gt$ (½)
$\Rightarrow 0 = 15.0 + (-1.60)t$ (½)
$\Rightarrow t = 15.0/1.60$
$= \underline{9.38 s}$ (1)

(b) (2 marks)
The height the rock reached above its point of release.

$h = ?$

$v^2 = u^2 + 2ah$ (½)
$0 = 15.0^2 + 2(-1.60)h.$
$\Rightarrow h = \frac{15.0^2}{2(-1.60)}$ (½)
$= 70.3$
∴ height reached is $\underline{7.03 \times 10^1 m}$ (1)

(c) (2 marks)
The rocks final velocity just before it impacts on the valley floor below. (82.0 m below the release point).

$s = -70.3 - 80.0$
$= -150.3 m$

$v^2 = u^2 + 2as$ (½)
$= 0 + 2 \times (-1.60) \times (-150.3)$ (½)
$= 480.96$
$\Rightarrow v = \sqrt{480.96}$
$= \pm 21.9 ms^{-1}$

∴ $\underline{V = 21.9 ms^{-1} \text{ down}}$
(½) (½)

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5. (a) (2 marks)
Tim visited a rifle range and found that a rifle tends to 'kick' after it is fired. Use the correct Newton's law to explain why it does this.

1 Newton's 3rd Law - 'for every action force there is an equal but opposite reaction force'

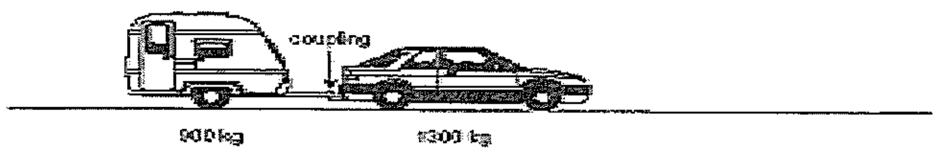
The rifle applies a force on the bullet and the bullet applies an equal but opposite force on the rifle - hence the rifle tends to 'kick' 1

(b) (2 marks)
Most buses have vertical steel poles attached to the seats and ceiling. Use the correct Newton's law to explain why this pole is there for standing passengers.

1 Newtons 1ST. Law - 'a body will remain at rest or continue at a constant velocity unless acted upon by a net force'

When the bus slows or speeds up, the standing passengers will continue to move with a constant
1 velocity. The pole is there so that standing passengers do not lose their balance and fall. The passengers velocity will also change to match that of the bus

6. (3 marks)
A car of mass 1.30×10^3 kg has a caravan of mass 9.00×10^2 kg attached to it. The car and caravan move off from rest.



If the car engine produces a forward force of 2.70×10^3 N, what is the tension in the coupling between the car and the caravan as they start to accelerate?

$m_{car} = 1.30 \times 10^3$ kg

$m_{caravan} = 9.00 \times 10^2$ kg

$u = 0.00$ ms^{-1}

$F_e = 2.70 \times 10^3$ N

$F_e = m_T a$ ½ m_T

$a = F_e / m_T$

$= 2.70 \times 10^3 / (1.30 \times 10^3 + 9.00 \times 10^2)$

$= 1.23$ ms^{-2} ½

Consider the caravan -

$F = m_{caravan} a$ ½

$= 9.00 \times 10^2 \times 1.23$ ½

$= 1.10 \times 10^3$ N forward

$\therefore$ Tension in cable is 1.10×10^3 N

½ ½

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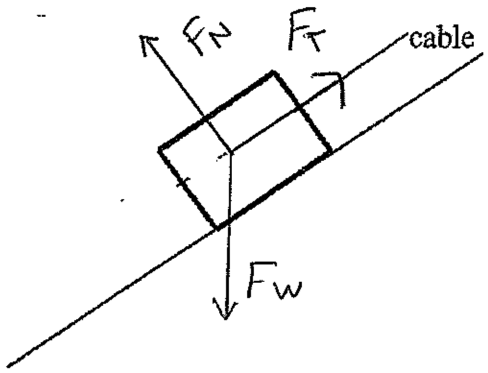
7. A cart of mass 18.0 kg is being held in place on a 40.0° slope by a cable which is parallel to the slope.



(a) (2 marks)
Draw a free body diagram showing all the forces acting on the block.

− 1 mark for each missing / incorrect force up to a total of 2 marks.

(b) (3 marks)
What is the tension in the cable needed to hold the cart in place on the slope?

$m = 18.0\text{kg}$
$g = -9.80\text{ms}^{-2}$
$\theta = 40.0°$

$= mg\sin\theta$ (1)
$= 18.0 \times (-9.80)\sin 40.0°$ (1)
$= -113\text{N}$

$\therefore$ Tension is $\underline{1.13 \times 10^2\ \text{N}}$ ($\frac{1}{2}$) ($\frac{1}{2}$)

(c) (3 marks)
When the cable breaks, it is found that it takes 1.40 s for the cart to Reach the bottom of the slope. How far up the slope was the cart originally?

$t = 1.40\text{s}$
$u = 0.00\text{ms}^{-1}$
$a = g\sin\theta$ ($\frac{1}{2}$)
$= -9.8\sin 40.0^2$
$= -6.30\text{ms}^{-2}$ ($\frac{1}{2}$)

$s = ut + \frac{1}{2}at^2$
$= 0 + \frac{1}{2} \times (-6.30) \times (1.40)^2$ (1)
$= -6.17\text{m}$ (1)

$\therefore$ cart was $\underline{6.17\text{ m up}}$ the slope

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8. (3 marks)
A car of mass 1.40 x 10^3 kg has a head-on collision with a large four-wheel drive vehicle of mass 2.20 x 10^3 kg, after which both cars stop. The four-wheel drive vehicle was travelling at 50.0 km h^{-1} prior to the collision in an area where the speed limit was 70.0 km h^{-1}. Was the car speeding? Show working below to verify the car's velocity immediately before collision.

$m_1 = 1.40\times10^3$ kg
$u_1 = ?$
$v_1 = 0.00 ms^{-1}$
$m_2 = 2.20\times10^3$ kg
$u_2 = -50.0 kmh^{-1}$
$= -50.0/3.6$
$= -13.9 ms^{-1}$ ½
$v_2 = 0.00 ms^{-1}$

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ ½
$1.40\times10^3 u_1 + 2.20\times10^3 \times(-13.9) = 1.40\times10^3\times0 + 2.20\times10^3\times0$ ½
$1.40\times10^3 u_1 - 30580 = 0$
$\Rightarrow u_1 = \frac{30580}{1.40\times10^3}$
$= 21.8 ms^{-1}$ ½

$21.8 ms^{-1} = 21.8\times3.6 kmh^{-1}$
$= 78.5 kmh^{-1}$ ½

½
∴ Yes, the car was speeding with a velocity of 78.5 kmh^{-1}

9. A driver with a mass of 80.0 kg is driving a car of mass 1.85 x 10^3 kg at 90.0 km h^{-1} and crashes into a concrete wall. In the collision the car comes to rest.

(a) (2 marks)
What is the car's change in momentum?

$m_c = 1.85\times10^3$ kg
$u = 90.0 kmh^{-1}$
$= 90.0/3.6$
$= 25 ms^{-1}$
$v = 0.00 ms^{-1}$

$\Delta p = m\Delta v$ ½
$= 1.85\times10^3\times(0-25)$ ½
$= -4.62\times10^4 kgms^{-1}$

∴ change in cars momentum is $-4.62\times10^4 kgms^{-1}$
½ ½

(b) (2 marks)
What impulse does the car undergo?

$I = \Delta p$ 1
$= -4.62\times10^4 kgms^{-1}$ 1

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(c) (2 marks)
If the car was stopped in 5.00 ms by the wall, what was the average force acting on the car?

$t = 5{\cdot}00\,ms$
$= 0{\cdot}005\,s$ $\frac{1}{2}$

$I = -4{\cdot}62\times10^{4}\,kgms^{-1}$
$F = ?$

$I = Ft$ $\frac{1}{2}$
$\Rightarrow F = I/t$
$= -4{\cdot}62\times10^{4}/0{\cdot}005$ $\frac{1}{2}$
$= \underline{-9{\cdot}24\times10^{6}\,N}$ $\frac{1}{2}$

(d) (2 marks)
Calculate the force on the driver during the collision.

$I = \Delta p = m\Delta v$ $\frac{1}{2}$
$= 80{\cdot}0\,(0 - 25)$
$= -2{\cdot}0\times10^{3}\,kgms^{-1}$ $\frac{1}{2}$

$F = I/t$ $\frac{1}{2}$
$= -2{\cdot}0\times10^{3}/0{\cdot}005 = \underline{-4{\cdot}00\times10^{5}\,N}$ $\frac{1}{2}$

(e) (4 marks)
What are two examples of safety features that are designed to reduce the force of impact on the driver? Explain how they reduce the force on the driver.

$\left.\begin{array}{l}\text{seat belts}\\ \text{air bags}\\ \text{crumple zones}\end{array}\right\}$ any 2 - 1 mark each

Δp does not change in the collision.
As $\Delta p = F.t$ to decrease the force acting on the driver, the time that the force acts over must increase. 1 The safety features listed above all increase the time it takes for the driver to come to a stop ie/ time that the force acts over and therefore the force on the driver is decreased. 1

END OF TEST

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