BELMONT CITY COLLEGE

PHYSICS 11:(2AB)

Forces and Energy Test 2012

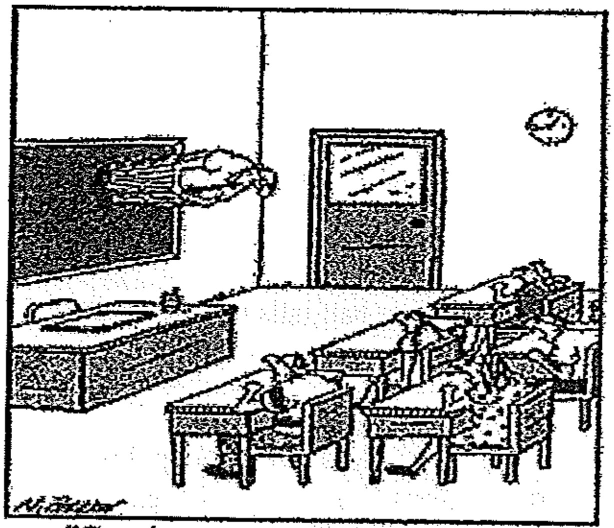
Name: Answers

Time: 1 Hour

* A data sheet is supplied for student use

Note:

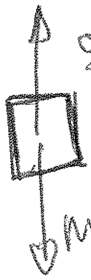
1. Calculations must show clear working with answers written in scientific notation stated to three significant figures..
2. Full Marks will be allocated for clear and logical setting out.
3. To help identify your answer, underline each answer.
4. State assumptions if working on open ended type questions.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



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

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.

$\Sigma F = 784 - 510 = 274\,N$ down



510

$mg = 80 \times 9.8 = 784$ N

$a = F/m = \frac{274}{80} = 3.42\,m s^{-2}$ 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?

$W = \Delta KE$
$= \frac{1}{2} m (v_2^2 - v_1^2)$
$= \frac{1}{2} \times 1500 (2.5^2 - 1^2) = 750(6.25 - 1)$
$= 3937.5 = 3940\,J.$

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?

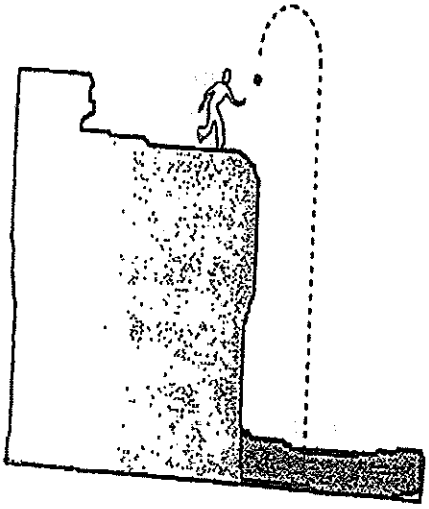
ΔE ~~Einitial~~ $= \Delta mgh = mg\Delta h$
$= 10 \times 9.8 \times (2) =$
$= 196\,J$

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

Lost as heat in ball/floor (caused by friction) + sound

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

let up = +ve direction



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.

$u = 15 \, ms^{-1}$
$v = 0$
$a = -1.6 \, ms^{-2}$
$t = ?$

$a = \frac{v-u}{t}$

$\Rightarrow -1.6 = \frac{-15}{t}$

$t = \frac{-15}{-1.6} = 9.38 \, s$

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

$s = ut + \frac{1}{2}at^2$
$= 15 \times 9.38 + \frac{1}{2}(-1.6)(9.38)^2$
$= 140.625 - 70.38752$
$\approx 70.2 \, m$

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

~~$v^2 = u^2 + a2as$~~

$v^2 = u^2 + 2as$
$= 15^2 + 2(-1.6)(-82)$
$= 225 + 262.4$
$v^2 = 487.4$

$v = 22.1 \, ms^{-1}$

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.

Newton's third law states that for every force there is an equal & opposite force.
Thus the force that propels the bullet (forward) has an equal & opposite force which propels the gun into Tim's shoulder. (ie. backward)

(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.

Newton's 1st law says an object will continue in constant motion unless a net force acts upon it

If the bus starts or stops suddenly, then there must be a force to accelerate or decelerate the people accordingly or they will tend to fall over. People provide this force by holding onto poles.

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?

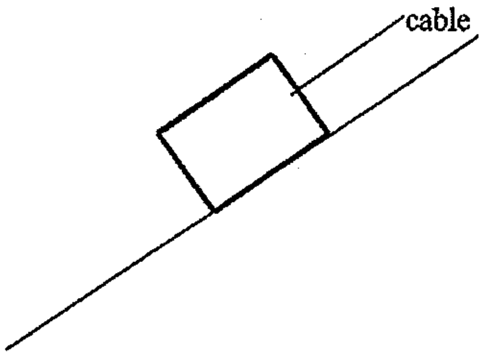
Total acceleration will be:

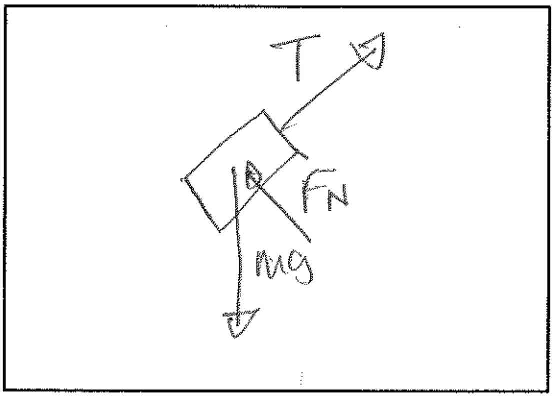
$$a = \frac{F}{m} = \frac{2700}{(1300+900)} = 1.22727 \, ms^{-2}$$

Force to accelerate the caravan at this rate:

$$F = ma = 900 \times 1.22727$$
$$= 1104.54 \text{ N}$$
$$= 11.0 \times 10^{1} \text{ N}$$

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

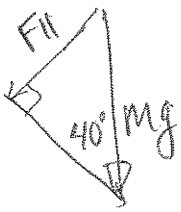




(a) (2 marks)
Draw a free body diagram in the box above showing all the forces acting on the block.

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

Component of gravitational force acting down ~~the~~ the slope ($F_{\parallel}$)



$\sin 40° = \frac{F_{\parallel}}{mg} \Rightarrow F_{\parallel} = mg\sin 40°$

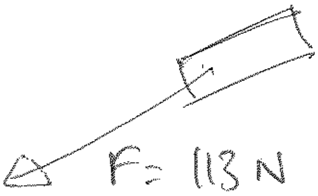
$= 113.3877$

$= \underline{113\ N}$

= Tension in cable.

(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?

in direction parallel to slope



$F = 113\ N$

$a = \frac{F}{m} = \frac{113}{18}$

$= \underline{6.30\ ms^{-2}}$

$s = ut + \frac{1}{2}at^2$

$= 0 \times t + \frac{1}{2} \times 6.30 \times 1.4^2$

$= \underline{6.17\ m}$

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.

If they came to a stop, then each car had equal momentum (equal & opposite)

ie $M_1V_1 = M_2V_2$

$\Rightarrow$ $1400 \times U = 2200 \times 50$

$U = 78.6$ km/h

Yes, it was speeding

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?

$\Delta p = p_2 - p_1 = 0 - mv$
$= 0 - 1850 \times (90 \div 3.6)$
$= -46250$ kgms^{-1}
$= 46200$ kgms^{-1} (in opposite direction to initial motion)

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

$I = \Delta p$
$= 46200$ N.s (away from wall.)

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

$I = F \times t = 46250$

$\Rightarrow \quad F = \dfrac{46250}{5 \times 10^{-3}} = 9.25 \times 10^{6}$ N (away from wall)

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

Assuming the driver comes to rest in same time

$I = F \times t = \Delta p$

ie $\quad F = \dfrac{mv}{t} = \dfrac{80 \times \left(\frac{90}{3.6}\right)}{5 \times 10^{-3}} = 4.00 \times 10^{5}$ N

(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.

Crumple zones : Increase the stopping time
Because the car & driver take longer to stop, the max force is reduced (since overall Impulse is the same for any given collision) $I = F \times t$
$\Rightarrow$ if t goes up ↑, F goes down ↓

Air Bags : Air bags increase the time of collision between the occupant and the dashboard (or door). As with crumple zones, increasing time of deceleration means decreasing maximum force)

END OF TEST

Seat belts : A little different, but I'm out of room ....

$$T = 2\pi\sqrt{\frac{L}{g}}$$

$$g \; \frac{L}{\left(\frac{T}{2\pi}\right)^2}$$

$$g = \frac{L}{\left(\frac{T}{2\pi}\right)^2}$$