Science 20 Unit B - Physics

Impulse is a change in momentum

Page 1

POS Checklist:

- [ ] define change in momentum as impulse ($mt = Ft$) and relate impulse to acceleration and Newton's second law of motion ($p/t = ma$), and apply the concept of impulse to explain the functioning of a variety of safety devices.

Page 2

the **LD** files

Another completely unrelated story from the life of LD...

LD recently gained a baby but is very worried about dropping him. Because nothing makes you look worse as a father than dropping your baby.

...Except maybe making your baby do this...

Page 3

As LD is a physicist, when he has a problem, he turns to physics.

So let's examine the information we know and formulate a hypothesis to solve LD's problem:

FACT: dropping babies is BAD
FACT: LD often has to hold his baby, say over the baby-change-table
FACT: Because of his clumbsyness, LD is bound to drop the baby once in a while.

What can LD do to not fail as a father?

Page 4

That's right! LD could put a pillow or cushion down so the baby wouldn't get hurt! But how does that work?

A cushion, mat or net slows down your landing. And if we assume that pain is caused by a force acting on the body, then there must be some relationship between the time and force.

Let's investigate this relationship between force and time.

Page 5

$$\vec{F} = \frac{\Delta\vec{p}}{\Delta t}$$

Recall that Newton wrote his Second Law in terms of momentum. This could be arranged as:

$$\Delta\vec{p} = \vec{F}\Delta t$$

From this, we can see that the product of force and time is momentum. Let's apply this to a real-life situation.

Page 6

Assume we have an egg with mass *m* and initial velocity $\vec{v}_i$, dropped from equal heights onto two different floors: one concrete floor and one with padding on it.

Page 7

- The $\vec{p}_i$ in each trial is the same as the mass and velocity of each egg is equal.
- The $\vec{p}_f$ are both 0 as the egg comes to a stop.
- This means the change in momentum is the same in each trial.

$$\Delta\vec{p} = \vec{p}_f - \vec{p}_i$$

Page 8

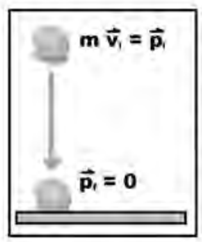
Now, just because the momentums are the same does not mean the force and time are the same:

eg) $\Delta p = F\Delta t$

12 Ns = (1 N)(12 s)
12 Ns = (2 N)(6 s)
12 Ns = (3 N)(4 s)
12 Ns = (4 N)(3 s) ...etc...

*Force and time can vary, but as one goes up, the other goes down if momentum must be the same.

Page 9

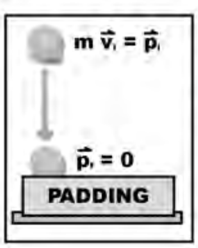


In the first trial, the time the egg takes to stop is very fast. **It hits the concrete and stops immediately. This means we have a small time and a large force to make up the momentum.**

$$\Delta\vec{p} = \vec{F}\,\Delta t$$

large force — small time

Page 10



In the second trial, the egg stops over a longer period of time. **This allows the same momentum change, but with a smaller force acting.**

$$\Delta\vec{p} = \vec{F}\,\Delta t$$

small force — large time

Page 11

In each of these trials, the change in momentum is the same. We call the change in momentum of an object the impulse.

$$\vec{F}\Delta t = m\Delta\vec{v}$$

Impulse is defined as the product of a force and the time interval that force acts over. It is the change in momentum an object experiences.

Impulse is a vector quantity.

Page 12

Note: this formula, along with all the others, can be found in your data booklet:

$\vec{p} = m\vec{v}$ $\qquad$ $\vec{F}\Delta t$ = impulse

$\Delta\vec{p} = \vec{F}\Delta t$, $\Delta\vec{p} = \vec{p}_f - \vec{p}_i$ $\qquad$ $\vec{p}$ = momentum (kg·m/s)

PAGE 2

Page 13

Impulse does not receive a symbol (other than Δp), but it does receive the units of Ns or kgm/s

ex) A force of 14.0 N acts on a 6.00 kg ~~bowling~~ bowling ball for 1.00 ms. What is the change in velocity of this object?

1 ms ÷ 1000 = 0.001 s

$\vec{F}\Delta t = m\Delta\vec{v}$

$(14N)(0.001s) = (6kg)\Delta\vec{v}$

$\Delta\vec{v} = 0.00233 m/s = 2.33\times10^{-3} m/s$

Ans = [redacted]

Page 14

ex) A 5.00 kg bird accelerates uniformly from rest to a velocity of 15.0 m/s East. What is the impulse on the object?

$\Delta\vec{p} = m\Delta\vec{v}$

$= (5 kg)(15 m/s)$

$= 75 kgm/s$

This is the change in velocity

Ans = [redacted]

Page 15

ex) A 1.0 kg ball hits the floor with a velocity of 2.0 m/s. If this ball bounces up with a velocity of 1.6 m/s, what is the ball's impulse?

* Recall → Δ = "change in" = final minus initial

$\Delta\vec{p} = m\Delta\vec{v}$

$= (1 kg)(1.6 m/s - 2 m/s)$

$= -0.40 kgm/s$

Ans = [redacted]

Page 16

Applications of Impulse

There are a number of applications of impulse in everyday life. Be familiar with these for your exam!

- **car crashes: old rigid cars vs. new crumpling cars**
- **"rolling with a punch" in boxing**
- **safety equipment in cars like air bags, new dashboards, steering columns**
- **helmets**
- **breaking a board with your fist!**
- **etc...**

Page 17

Practice: Page 256 #5-12

Page 18