Rolling down a wide gutter

Title: Rolling down a wide gutter

Aim: To show the effect of rolling radius on the amount of rotational kinetic energy.

Subjects: 1Q10 (Momentum of Inertia)
1Q20 (Rotational Energy)

Diagram:

Equipment:

- Two gutters of different width.
- Two equal, large basketballs.

In case of errors, please contact: E.Balsma@tudelft.nl

Delft University of Technology

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Presentation: Both gutters are inclined about 7°. The balls start rolling down at the same time. The ball that rolls down the wider gutter takes much more time to reach the horizontal plane as the one rolling down the narrow gutter.

Explanation: One ball ('A') rolls with a larger radius than the other ('B'). So 'A' makes less rotations along the ramp than 'B'. That's why ball 'A' needs a smaller part of the available potential energy for its rotation to reach the end of the track and so more energy is available for its translation.
$E_{pot}=E_{transl}+E_{rot}$.
$E_{transl}=1/2mv^2$; $E_{rot}=1/2I\omega^2$, with $I=2/3mR^2$ (thin-walled hollow sphere).
When a ball rolls down the gutter, then $v=\omega r$ (r being the radius of rotation) and we find: $E_{transl}/E_{rot}=(3/2)(r^2/R^2)$.
When the gutter is very narrow, $r=R$ and $E_{transl}/E_{rot}=3/2$. So 60% of the pot. energy is transformed in translation of the ball and 40% in rotation.
Our wider gutter has dimensions such that $r=1/2R$, and so $E_{transl}/E_{rot}=3/8$. Now 27% of the pot. energy is transformed into translation of the ball and 73% in rotation.
Comparing these two rolling balls, ball 'A' obtains 2.2 times as much energy for its translation as ball 'B' does. This means that ball 'A' has at the end of the gutter a transl. speed almost 50% higher than ball 'B' ($2.2^{1/2}=1.48$). Then the time ball 'B' needs to travel along the gutter will also be 50% higher.

Remarks:

- The balls must be pumped firmly, otherwise the ball in the wide gutter will experience too much friction.

Sources:

- Friedrich, Artur, Handbuch der experimentellen Schulphysik, part 2, Mechanik der festen Körper, pag. 212
- Ehrlich, Robert, Turning the World Inside Out and 174 Other Simple Physics Demonstrations, pag. 53-55