

# Some Useful Equations and Tables for the Digitisation of Taped Sound Collections

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## Abstract

This document contains conversion tables and equations that have been useful while digitising the Natural History Museum's collection of recorded wildlife sound as part of the BioAcoustica project [2].

## Contents

<b>1</b>	<b>Tape Speed Conversion</b>	<b>1</b>
<b>2</b>	<b>Tape Increment Counters</b>	<b>1</b>
<b>3</b>	<b>Reel and tape measurements</b>	<b>4</b>

## 1 Tape Speed Conversion

Due to limitations on the hardware currently available it is not always possible to digitise recordings at the tape speed they were originally recorded at. Various software can be used to change the speed of the recording after digitisation. The following tape speed conversion tables are based on that first published by this author [1]. Table 1 gives the speed multipliers, Table 1 gives the percentage change. The most useful will depend on which software you use to perform the conversion.

## 2 Tape Increment Counters

The BioAcoustica collection consists at present largely of material from the Natural History Museum's Sound Collection. These recordings exist on over 800 reel-to-reel tapes, often with several recordings per tape. The position at which each recording starts is given in an accompanying metadata sheet (FIG X). There are also recordings where typed annotations are provided (FIG X).

From	To					
	2.38	4.76	9.53	19.05	38.1	76.2
2.38	1	0.5	0.25	0.125	0.0625	0.03125
4.76	2	1	0.5	0.25	0.125	0.0625
9.53	4	2	1	0.5	0.25	0.125
19.05	8	4	2	1	0.5	0.25
38.1	16	8	4	2	1	0.5
76.2	32	16	8	4	2	1

Table 1: Speed multipliers for tape digitisation speeds

From	To					
	2.38	4.76	9.53	19.05	38.1	76.2
2.38	0	-50	-75	-87.5	-93.75	-96.875
4.76	100	0	-50	-75	-87.5	-93.75
9.53	300	100	0	-50	-75	-87.5
19.05	700	300	100	0	-50	-75
38.1	1500	700	300	100	0	-50
76.2	3100	1500	700	300	100	0

Table 2: Percentage change for tape digitisation speeds

The tape position indicators are based on the number of turns made by the tape reel, rather than a linear quantity related to time or length of tape played. When it came to digitising these tape reels using a more modern player that indicated position in MM:SS format a method of converting between the original indicator positions as listed in the metadata documents and the position along the tape in seconds was required.

The tape player originally used had a position indicator that incremented twice for each full turn of the wheel. Using the method of [3] the number of rotations can be converted to time by considering the 'edge' area of played tape. The edge area of played tape is given by the area of the rectangle  $utd$ , which is nearly equal to the area of the ring of tape on the receiving spool.

$$A_p = utd \quad (1)$$

$$A_u = \pi r(t)^2 - \pi r_h^2 \quad (2)$$

At time  $t$ ,  $A_p = A_u$ :

$$utd = \pi[r(t)^2 - r_h^2]$$

$$r(t) = \pm \sqrt{\frac{utd}{\pi} + r_h^2}$$

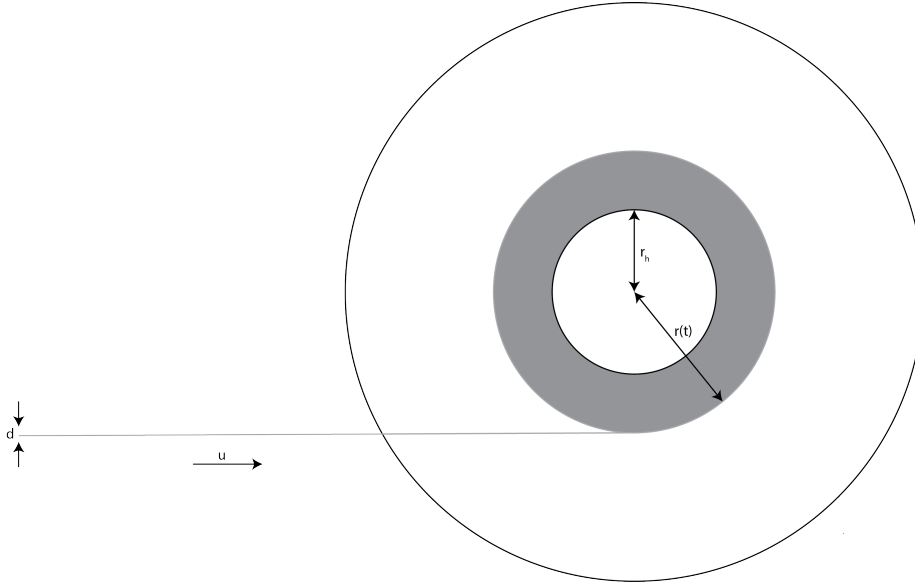


Figure 1: Tape area.

$$r(t) \geq r_h; r_h > 0$$

$$\Rightarrow r(t) = \sqrt{\frac{utd}{\pi} + r_h^2} \quad (3)$$

Number of turns,  $n(t)$ :

$$n(t) = \frac{r(t) - r_h}{d} \quad (4)$$

Sub in Equation 3

$$n(t) = \frac{\sqrt{\frac{utd}{\pi} + r_h^2} - r_h}{d} \quad (5)$$

Indicator is scaled by  $k$ :

$$I(t) = k \times n(t) \quad (6)$$

Sub in Equation 5

$$I(t) = k \frac{\sqrt{\frac{utd}{\pi} + r_h^2} - r_h}{d} \quad (7)$$

Re-arranging for  $t$ :

$$t = \frac{\pi}{ud} \left[ \left( \frac{I(t)d}{k} + r_h \right)^2 - r_h^2 \right] \quad (8)$$

Manufacturer	Model	Hub Diameter	Overall Diameter
BASF	5 inch	46.6	126
BASF	7 inch	60.8	176
BASF Magnetophonband	7 inch	60.2	176
Emitape	3 inch	32.0	75.4
Emitape	5 inch	45.0	127
Emitape	7 inch	60.1	178
Gevaert	5 inch	41.0	128
Grundig	7 inch	58.9	177
Scotch/3M	3 inch	31.8	76.4
ScotchBoy (Minnesota Mining & Manufacturing Co Ltd) UK	7 inch	57.8	177
Scotch (Minnesota Mining & Manufacturing Co) USA	5 inch	44.6	127

Table 3: Measurement of plastic reels holding tape, by reel manufacturer.

Manufacturer	Model	Thickness
BASF	LGS	0.04-0.05
BASF	LGS35	0.03-0.04
BASF	LGS52	0.05

Table 4: Measured tape thickness by brand and model.

### 3 Reel and tape measurements

Measurements of reel hub diameter and tape thickness are important for making use of the equations in Section 2. Table 3 provides measurement of the plastic reels used to hold tape in the NHM collection. Table 3 provides measurements of tape thickness for brands and models present in the NHM collection.

## References

- [1] Ed Baker. *BioAcoustica: Tape speed conversion table*. URL: <http://pblog.ebaker.me.uk/2015/04/bioacoustica-tape-speed-conversion-table.html>.
- [2] Ed Baker et al. “BioAcoustica: A free and open repository and analysis platform for bioacoustics”. In: *Database 2015.bav054* (2015). DOI: 10.1093/database/bav054.
- [3] Frank Budden. “63.14 Cassette tapes”. In: *Mathematical Gazette* 1979 (June 1979), pp. 113–116.