

Momentum-Transfer First Scoring Model

Overview

The BARRELS scoring engine has been refactored to implement a **momentum-transfer and timing first** approach, where the quality of energy transfer from Anchor → Engine → Whip is the primary driver of the score.

Core Philosophy

“Momentum Transfer Score (MTS): How well does energy/speed hand off from lower body → core → arms/bat over time?”

Scoring Breakdown

Final Mechanics Score (0-100):

```
mechanicsScore =  
  0.60 × momentumTransferScore +  
  0.15 × anchorScore +  
  0.15 × engineScore +  
  0.10 × whipScore
```

- **Momentum Transfer (60%):** Global timing & sequencing quality
- **Anchor (15%):** Lower body momentum setup
- **Engine (15%):** Core momentum amplification
- **Whip (10%):** Arms/bat momentum release

Momentum Transfer Score (MTS)

Components (weighted):

1. **Sequence Order Score (30%)**
 - Correct pelvis → torso → hands → bat order
 - 100 = perfect order
 - 75 = one adjacent swap
 - 50 = two segments out of order
 - 25 = clearly broken
2. **Timing Gap Scores (40% total)**
 - **Pelvis→Torso Gap (15%):** Ideal 30-50ms
 - **Torso→Hands Gap (15%):** Ideal 35-55ms
 - **Hands→Bat Gap (10%):** Ideal 20-40ms
 - Uses tolerance band scoring
3. **Deceleration Quality Score (15%)**
 - Upstream segments should decelerate while downstream peaks

- Checks pelvis decel before torso peak
- Checks torso decel before hands peak

4. **Smoothness Score (10%)**

- Uses pelvis jerk metric (lower = smoother)
- Smooth momentum flow = higher score

5. **A-B-C Tempo Score (5%)**

- Evaluates Load (A→B) and Swing (B→C) durations
- Rewards consistent A:B:C ratio

Sub-Scores

Anchor Score (Lower Body)

Question: “How well does the lower body set up and launch momentum transfer?”

Calculation:

```
anchorScore =
  0.70 × comBalance +    // pelvis trajectory, weight transfer
  0.30 × posture         // base stability
```

Engine Score (Core/Torso)

Question: “Does the torso accept and amplify what the Anchor gives it?”

Calculation:

```
engineScore =
  0.60 × sequence +      // kinematic chain timing
  0.40 × tempo           // A-B-C timing
```

Whip Score (Arms/Bat)

Question: “Did the arms and bat accept upstream energy and release it at the right moment?”

Calculation:

```
whipScore = handPath    // efficiency and barrel delivery
```

Momentum Transfer Caps

Global Rule: MTS Caps Everything

To prevent “pretty positions, bad flow” scores:

- **If MTS < 40:** Cap final score at **60**
- **If MTS < 50:** Cap final score at **70**

A hitter **cannot** achieve a high score through position alone with broken timing/sequencing.

Calibration Targets

MTS Bands:

- **90-100**: Elite transfer (MLB all-star level)
- **80-89**: Pro / D1 level transfer
- **70-79**: Advanced amateur
- **60-69**: Solid but leaky
- **< 60**: Major sequencing or timing issues

Expected Final Scores:

- **MLB hitters**: 85-95 (consistent good sequencing)
 - **College/HS**: 65-80
 - **Youth/Poor mechanics**: < 60
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Configuration

All weights and thresholds are in `lib/scoring/config.ts` :

Composite Weights:

```
export const COMPOSITE_WEIGHTS = {
  momentumTransfer: 0.60,
  anchor: 0.15,
  engine: 0.15,
  whip: 0.10,
};
```

Momentum Transfer Component Weights:

```
export const MOMENTUM_TRANSFER_WEIGHTS = {
  sequenceOrderScore: 0.30,
  pelvisTorsoGapScore: 0.15,
  torsoHandsGapScore: 0.15,
  handsBatGapScore: 0.10,
  decelQualityScore: 0.15,
  smoothnessScore: 0.10,
  abcTempoScore: 0.05,
};
```

Penalties:

```
export const PENALTIES = {
  momentumTransferCaps: {
    enabled: true,
    cap70Threshold: 50,
    cap60Threshold: 40,
  },
  // ...
};
```

Debug API

Endpoint:

```
GET /api/dev/videos/[videoId]/scoring-debug
```

Response includes:

```
{
  "momentumTransferScore": 82,
  "momentumComponents": {
    "sequenceOrderScore": 100,
    "pelvisTorsoGapScore": 85,
    "torsoHandsGapScore": 78,
    "handsBatGapScore": 90,
    "decelQualityScore": 70,
    "smoothnessScore": 88,
    "abcTempoScore": 80
  },
  "anchorScore": 76,
  "engineScore": 82,
  "whipScore": 78,
  "finalMechanicsScore": 80,
  "debugBreakdown": { /* full breakdown */ }
}
```

Implementation Details

Files Modified:

1. lib/scoring/types.ts

- Added MomentumTransferComponents interface
- Added MomentumTransferScore interface
- Added SubScores interface
- Updated ScoringResult with momentum transfer data
- Updated DebugBreakdown structure

2. lib/scoring/config.ts

- Added COMPOSITE_WEIGHTS
- Added MOMENTUM_TRANSFER_WEIGHTS
- Added momentumTransferCaps penalty

3. lib/scoring/newScoringEngine.ts

- Added calculateMomentumTransferScore() function
- Added calculateDecelQualityScore() function
- Added calculateAnchorScore() function
- Added calculateEngineScore() function
- Added calculateWhipScore() function
- Updated scoreSwing() to use new model
- Updated buildDebugBreakdown() with momentum data

4. `app/api/dev/videos/[id]/scoring-debug/route.ts`

- Enhanced response to show momentum transfer scores at top level
- Added composite weights to config output

Key Changes from Previous Model

Before (Category-based):

```
mechanicsScore =
  0.35 × sequence +
  0.25 × tempo +
  0.15 × comBalance +
  0.15 × handPath +
  0.10 × posture
```

After (Momentum-Transfer First):

```
mechanicsScore =
  0.60 × momentumTransferScore +
  0.15 × anchor +
  0.15 × engine +
  0.10 × whip
```

Why?

- Timing & sequencing now dominate (60% vs 35%)
- Position-based metrics (Anchor/Engine/Whip) are supporting factors
- Caps prevent high scores with poor momentum transfer
- MLB-calibrated: Good sequencers always score higher

Tuning Guide

To adjust calibration:

1. **Increase MTS importance:** Raise `COMPOSITE_WEIGHTS.momentumTransfer` (max 0.80)
2. **Emphasize sequence order:** Raise `MOMENTUM_TRANSFER_WEIGHTS.sequenceOrderScore`
3. **Tighten timing gaps:** Adjust `THRESHOLDS.pelvisTorsoGap` ideal range
4. **Stricter caps:** Raise `cap70Threshold` to 55-60
5. **Test with real swings:** Use debug API to inspect MTS components

Testing

Unit Testing:

1. Upload videos at different skill levels
2. Check MTS scores via debug API
3. Verify caps are applied when MTS < 50

4. Ensure MLB swings score 85+

Expected Behavior:

- ☒ MLB with good sequence: 85-95
 - ☒ Amateur with broken sequence: capped at 60-70
 - ☒ HS with solid timing: 70-80
 - ☒ Youth with poor flow: < 60
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Rollback

To revert to the old model:

```
// lib/scoring/config.ts
export const NEW_SCORING_ENGINE_ENABLED = false;
```

Then redeploy.